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Background Information for Proposed Standards

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This document contains information used as the basis for developing proposed New Source Performance Standards for the metal coil surface coating industry. The document includes an industry description, descriptions of model plants and regulatory alternatives considered, and environmental, energy, and economic impact analyses of the regulatory alternatives.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
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ENVIRONMENTAL PROTECTION AGENCY

Background Information and Draft Environmental Impact Statement for Metal Coil Surface Coating

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1. The proposed standards of performance would limit emissions of volatile organic compounds from new, modified, and reconstructed metal coil surface coating operations. Section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, directs the Administrator to establish standards of performance for any category of new stationary sources of air pollution that ". . . causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare." The industrial centers of the Northeast and Midwest will be particularly affected by the proposed standards.

2. Copies of this document have been sent to the following Federal Departments: Labor, Health and Human Services, Defense, Transportation, Agriculture, Commerce, Interior, and Energy; the National Science Foundation; the Council on Environmental Quality; members of the State and Territorial Air Pollution Program Administrators; the Association of Local Air Pollution Control Officials; EPA Regional Administrators; and other interested parties.

3. The comment period for review of this document is 60 days. Mr. Gene Smith may be contacted regarding the date of the comment period.

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TABLE OF CONTENTS

Page

1. SUMMARY 1-1
   1.1 Regulatory Alternatives 1-1
   1.2 Environmental Impact 1-1
   1.3 Economic Impact 1-2
   1.4 Energy Impact 1-2

2. INTRODUCTION 2-1
   2.1 Background and Authority for Standards 2-1
   2.2 Selection of Categories of Stationary Sources 2-4
   2.3 Procedure for Development of Standards of Performance 2-6
   2.4 Consideration of Costs 2-8
   2.5 Consideration of Environmental Impacts 2-9
   2.6 Impact on Existing Sources 2-10
   2.7 Revision of Standards of Performance 2-11

3. THE COIL COATING INDUSTRY 3-1
   3.1 General 3-1
   3.2 Coil Coating Processes and Emissions 3-1
   3.3 Baseline Emissions 3-8
   3.4 References 3-10

4. EMISSION CONTROL TECHNIQUES 4-1
   4.1 Introduction 4-1
   4.2 Description of Industry Control Techniques 4-1
      4.2.1 Thermal Incineration 4-2
         4.2.1.1 Zone Incineration 4-4
         4.2.1.2 Regenerative Heat Recovery 4-5
         4.2.1.3 Recuperative Heat Recovery 4-5
         4.2.1.4 Direct Recycle Heat Recovery 4-6
      4.2.2 Catalytic Incineration 4-7
      4.2.3 Coating Rooms 4-8
      4.2.4 Waterborne Coatings 4-9
      4.2.5 Other Control Methods 4-10
   4.3 References 4-11

5. MODIFICATIONS AND RECONSTRUCTION 5-1
   5.1 Descriptions of Typical Modifications and Reconstruction . . . 5-1
   5.2 Retrofit Considerations 5-2
   5.3 References 5-3

CONTENTS (continued)

Page

6. MODEL PLANTS AND REGULATORY ALTERNATIVES 6-1
6.1 Model Plants. 6-1
6.2 Regulatory Alternatives 6-7

7. ENVIRONMENTAL IMPACT 7-1
7.1 Air Pollution Impact. 7-1
7.2 Water Pollution Impact. 7-8
7.3 Solid Waste Disposal Impact 7-9
7.4 Energy Impact 7-9
7.5 Other Environmental Concerns. 7-14
7.5.1 Irreversible and Irretrievable Commitment of Resources. 7-14
7.5.2 Environmental Impact of Delayed Standards. 7-14
7.6 References. 7-14

8. ECONOMIC IMPACT. 8-1
8.1 Industry Chacterization 8-1
8.1.1 General Profile. 8-1
8.1.2 Trends 8-17
8.1.2.1 Historical Trends 8-17
8.1.2.2 Future Trends 8-19
8.2 Cost Analysis of Control Options. 8-22
8.2.1 Introduction 8-22
8.2.2 New Facilities 8-30
8.2.2.1 Capital Costs 8-30
8.2.2.2 Annualized Costs. 8-32
8.2.2.3 Cost Effectiveness. 8-35
8.2.2.4 Base Cost of Facility 8-40
8.2.3 Modified/Reconstructed Facilities. 8-47
8.3 Other Cost Considerations 8-50
8.3.1 The Clean Water Act. 8-52
8.3.2 Occupational Exposure. 8-52
8.3.3 Toxic Substances Control 8-55
8.4 Economic Impact Analysis. 8-55
8.4.1 Summary. 8-56
8.4.2 Economic Conditions in the Industry. 8-57
8.4.2.1 Industry Structure. 8-58
8.4.2.2 Industry Performance. 8-60
8.4.3 Methodology. 8-62
8.4.3.1 Discounted Cash Flow Approach 8-62
8.4.3.2 Project Ranking Criterion 8-66
8.4.3.3 Determining the Impacts of the Regulatory Alternatives 8-67
8.4.4 Economic Impacts on New Facilities 8-68
8.4.4.1 Price Impacts 8-71
8.4.4.2 Return on Investment Impacts. 8-71
8.4.4.3 Incremental Capital Requirements. 8-71
8.4.4.4 Summary 8-75

CONTENTS (continued)

Page
8.4.5 Economic Impacts on Modified Facilities. 8-76
8.4.5.1 Price Impacts 8-79
8.4.5.2 ROI Impacts 8-79
8.4.5.3 Incremental Capital Requirements. 8-79
8.4.5.4 Summary 8-83
8.5 Potential Socioeconomic and Inflationary Impacts. 8-83
8.5.1 Annualized Cost Criterion. 8-84
8.5.2 Product Price Criterion. 8-84
8.6 Financial Data for Coil Coating Firms 8-88
8.7 References. 8-91

Appendix A: Evolution of the Background Information Document. A-1
Appendix B: Index to Environmental Impact Considerations. B-1
Appendix C: Emission Source Test Data C-1
Appendix D: Emission Measurement and Continuous Monitoring. D-1
Appendix E: Revised Regulatory Alternatives E-1

LIST OF FIGURES

Number Page

3-1 Schematic diagram of a coil coating line. 3-3

6-1 Schematic diagram of model coil coating line. 6-2

6-2 List of model plant parameters for small plant with 1 coating line. 6-4

6-3 List of model plant parameters for medium plant with 1 coating line. 6-5

6-4 List of model plant parameters for large plant with 1 coating line. 6-6

7-1 List of States and major metropolitan areas currently regulating organic solvent emissions through specific numerical standards. 7-3

7-2 List of States not regulating organic solvent emissions through specific numerical standards. 7-4

8-1 Total projected shipments of precoated metal: 1981-1985. . . . 8-20

8-2 List of parameters for model coil coating lines 8-24

8-3 Schematic diagram of a model coil coating line with thermal incineration and primary and secondary heat recovery (Control Option 2) 8-29

LIST OF TABLES

Number		Page
1-1	Assessment of Environmental and Economic Impacts for Each Regulatory Alternative Considered	1-3
3-1	Coatings Used in Coil Coating	3-4
4-1	Emission Test Results for Thermal Incinerators on Coil Coating Lines	4-3
7-1	Estimated Environmental Impacts	7-7
7-2	Rate of Fuel Energy Usage of Model Coil Coating Lines	7-10
7-3	Rate of Electrical Energy Usage of Model Coating Lines	7-11
7-4	Estimated Annual Increase in National Fuel Consumption Due to Industry Growth	7-13
8-1	Domestic Coil Coating Establishments Currently in Operation: 1979	8-3
8-2	Current and Suggested End Uses of Precoated Metal Strip	8-8
8-3	Coatings, Prices, and Metals Coated	8-14
8-4	Shipments of Precoated Aluminum and Steel: 1976 and 1977	8-15
8-5	Major Markets for Precoated Metal: 1976 and 1977	8-16
8-6	Estimate of Total Shipments of Prepainted or Precoated Metal Coil by Coaters Located in the United States, Canada, and Mexico	8-18
8-7	Regulatory Alternatives and Control Options Considered in the Economic Analysis	8-23
8-8	Key Parameters for Control Option 1: Multiple Zone Incinerators and Coating Rooms	8-25
8-9	Key Parameters for Control Option 2: Thermal Incineration with Heat Recovery	8-26

LIST OF TABLES (continued)

Number Page

8-10 Key Parameters for Control Option 3: Thermal Incineration with Heat Recovery and Coating Rooms. 8-27

8-11 Capital Costs of Control Options 8-31

8-12 Component Capital Cost Factors Used in Calculating Total Installed Costs. 8-33

8-13 Calculation of Annualized Costs of Air Pollution Control Systems. 8-34

8-14 Annual Operating Costs of Control Options. 8-36

8-15 Annualized Cost of VOC Control Options for Small Model Line 8-37

8-16 Annualized Costs of VOC Control Options for Medium Model Line 8-38

8-17 Annualized Costs of VOC Control Options for Large Model Line 8-39

8-18 Marginal Cost Effectiveness of NSPS Above SIP Regulations for Small Model Line 8-41

8-19 Marginal Cost Effectiveness of NSPS Above SIP Regulations for Medium Model Line. 8-42

8-20 Marginal Cost Effectiveness of NSPS Above SIP Regulations for Large Model Line 8-43

8-21 Capital Costs of New Coil Coating Facilities 8-44

8-22 Annual Operating Costs of Model Coil Coating Lines Without Emission Control Equipment 8-46

8-23 Increase in Annual Operating Costs of Existing Lines Having CTG Control Systems Due to Increased Production and Additional Emission Control. 8-49

8-24 Increase in Annual Operating Costs of Existing Lines Having 85 Percent Control Due to Increased Production and Additional (95 Percent Overall) Emission Control to Meet NSPS. 8-51

8-25 Threshold Limit Values (TLV) and Lower Explosive Limits (LEL) of Typical Solvents. 8-54

LIST OF TABLES (continued)

Number Page

8-26 Concentration Ratios in the Metal Coating and Allied Services Industry. 8-59

8-27 Selected Financial Statistics for the Coil Coating Industry, 1976-1978 8-61

8-28 Definitions 8-64

8-29 Summary Cost Data for New Facilities 8-69

8-30 Unit Prices and Rankings for New Facilities 8-70

8-31 Price Impacts of Regulatory Alternatives on New Facilities 8-72

8-32 Return on Investment Impacts of Regulatory Alternatives on New Facilities. 8-73

8-33 Incremental Capital Requirements of Regulatory Alternatives for New Facilities 8-74

8-34 Summary Cost Data for Modified Facilities 8-77

8-35 Unit Prices and Rankings for Modified Facilities. 8-78

8-36 Price Impacts of Regulatory Alternatives on Modified Facilities 8-80

8-37 Return on Investment Impacts of Regulatory Alternatives on Modified Facilities. 8-81

8-38 Incremental Capital Requirements of Regulatory Alternatives for Modified Facilities. 8-82

8-39 Incremental Annualized Cost of Compliance With Regulatory Alternative III, 1985. 8-85

8-40 Overall Price Impact of Regulatory Alternative III. 8-87

8-41 Financial Statistics for Coil Coating Firms 8-89

8-42 Yields by Rating Class for Cost of Debt Funds, 1979 8-92

1. SUMMARY

Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended directs the Administrator to establish standards of performance for any category of new stationary sources of air pollution that "causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health and welfare." The metal coil surface coating industry falls into this classification, and standards of performance have been developed for volatile organic compound (VOC) emissions from this industry.

1.1 REGULATORY ALTERNATIVES

Five regulatory alternatives are considered. The first involves no additional regulation. Emissions from new, modified, or reconstructed metal coil coating plants would continue to be governed by State regulations.

The second regulatory alternative would limit emissions to those resulting from the use of the best available emission control device in conjunction with current industry practice for capturing VOC emissions.

The third regulatory alternative is the same as the second, except that a separate, higher emission limit would be included for plants that use low-VOC content coatings.

The fourth regulatory alternative would limit emissions to those resulting from the use of the best available emission control device and would require that coating application stations be enclosed in rooms.

The fifth regulatory alternative is the same as the fourth, except that a separate, higher emission limit would be included for plants that use low-VOC content coatings.

1.2 ENVIRONMENTAL IMPACT

Under Regulatory Alternative I, there would be no environmental impact, either beneficial or adverse. Under Regulatory Alternative II, VOC emissions would be reduced by 1,915 megagrams (Mg) per year in 1985; under Regulatory Alternative III, they would be reduced by 1,815 Mg; under Regulatory Alternative IV, they would be reduced by 3,605 Mg; and, under Regulatory Alternative V, they would be reduced by 3,200 Mg. No adverse impacts on water, solid waste, or noise would be expected from any of the regulatory alternatives. A matrix summarizing the environmental, energy, and economic impacts is presented in Table 1-1.

1.3 ECONOMIC IMPACT

Under Regulatory Alternative I, no economic impact would result for the coil coating industry. Under Regulatory Alternatives II, III, IV, or V, the price of coil coated metal could be expected to increase by 2.0 to 3.1 percent nationally after 5 years. Price increases at individual plants could be either higher or lower than this national figure.

1.4 ENERGY IMPACT

Under Regulatory Alternative I, no energy impact would occur, but for Regulatory Alternatives II through V, energy consumption by the coil coating industry would be expected to increase by about 1 percent per year above the current level. In the fifth year, the increase in energy consumption would be equivalent to about 200,000 barrels of oil.

TABLE 1-1. ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC IMPACTS FOR EACH REGULATORY ALTERNATIVE CONSIDERED

Administrative action	Air impact	Water impact	Solid waste impact	Energy impact	Noise impact	Economic impact
Regulatory Alternative I	0	0	0	0	0	0
Regulatory Alternative II	+2[a]	0	0	-1[a]	0	-2[a]
Regulatory Alternative III	+2[a]	0	0	-1[a]	0	-2[a]
Regulatory Alternative IV	+3	0	0	-1	0	-3
Regulatory Alternative V	+3	0	0	-1	0	-3
Delayed standards	-1	0	0	0	0	0

[a] Long-term impact.

KEY:
+ Beneficial impact
- Adverse impact
0 No impact
1 Negligible impact
2 Small impact
3 Moderate impact

2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control, based on different technologies and degrees of efficiency, are expressed as regulatory alternatives. Each of these alternatives is studied by the U.S. Environmental Protection Agency (EPA) as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, their impacts on the national economy, and their impacts on the environment. This document summarizes the information obtained through these studies so that interested persons will be able to see the information considered by EPA in the development of the proposed standard.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, herein referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution that "causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect "the degree of emission reduction achievable which (taking into consideration the cost of achieving such emission reduction, and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated for that category of sources." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance:

- EPA is required to list the categories of major stationary sources that have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:
  - 25 percent of the listed categories by August 7, 1980
  - 75 percent of the listed categories by August 7, 1981
  - 100 percent of the listed categories by August 7, 1982.

  A governor of a State may apply to the Administrator to add a category not on the list or to have a standard of performance revised.
- EPA is required to review the standards of performance every 4 years and, if appropriate, revise them.
- EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.
- The term standards of performance is redefined, and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low-polluting or nonpolluting process or operation.
- The time between the proposal and promulgation of a standard under Section 111 of the Act may be extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, with the cost of achieving such emission reduction, any nonair quality health and environmental impacts, and energy requirements being considered.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to prevent situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting if pollution ceilings are reduced in the future. Fourth, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that New Source Performance Standards (NSPS) contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term best available control technology (BACT), as defined in the Act, means

> . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from, or which results from, any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to Sections 111 or 112 of this Act. (Section 169(3))

Although standards of performance are normally structured in terms of numerical emission limits, where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions--high concentrations for short periods during filling and low concentrations for longer periods during storage--and the configuration of storage tanks make direct emission measurement impractical. Therefore, equipment specification has been a more practical approach to standards of performance for storage vessels.

In addition, Section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require or an equivalent reduction at lower economic, energy, or environmental costs; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare, or safety; (4) the governor of the State where the source is located consents; and (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure that the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to meet the standards with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources. The Administrator "shall include a category of sources in such list if in his judgment it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants emitted by stationary sources. Source categories that emit these pollutants are evaluated and ranked by a process involving such factors as (1) level of emission control (if any) already required by State regulations, (2) estimated levels of control that might be required from standards of performance for the source category, (3) projections of growth and replacement of existing facilities for the source category, and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which an NSPS was promulgated or under development during 1977 or earlier were selected based on these criteria.

The Clean Air Act amendments of August 1977 establish specific criteria to be used in determining priorities for all major source categories not yet listed by EPA. These are (1) the quantity of air pollutant emissions that each such category will emit, or will be designed to emit; (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases it may not be feasible immediately to develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the development of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inablility to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from some of these facilities may vary from insignificant to very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, the nonair quality health and environmental impacts, and the energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed, as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for developing standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard setting process involves three principal phases of activity: (1) information gathering, (2) analysis of the information, and (3) development of the standard of performance.

During the information gathering phase, industries are queried through a telephone survey, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from many other sources, and a literature search is conducted. From the knowledge acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several possibly applicable alternatives, EPA selects the single most plausible regulatory alternative as the basis for a standard of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard of performance, which, in turn, is written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee (NAPCTAC). Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the Background Information Document (BID). The BID, the standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are considered as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standard is officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

As a part of the Federal Register announcement of the proposed regulation, the public is invited to participate in the standard-setting process. EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standards with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, D.C.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the "preamble" of a "promulgation package," which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance; (2) the potential inflationary or recessionary effects of the regulation; (3) the effects the regulation might have on small business with respect to competition; (4) the effects of the regulation on consumer costs; and (5) the effects of the regulation on energy use. Section 317 also requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and in terms of the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is necessary because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact from the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed in plants so additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decisionmaking process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the U.S. Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry. On this basis, therefore, the Court established a narrow exemption from NEPA for EPA determination under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements.

According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793c(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102 (2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under Section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section in this document is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as "any stationary source, the construction or modification of which is commenced" after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the general provisions of Subpart A of 40 CFR Part 60, which were promulgated in the Federal Register on December 16, 1975. (40 FR 58416)

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under Section 111 (d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60. (40 FR 53340)

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator "shall, at least every 4 years, review and, if appropriate, revise" the standards. Revisions are made to ensure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive, but will apply to stationary sources constructed or modified after proposal of the revised standards.

3. THE COIL COATING INDUSTRY

3.1 GENERAL

The coil coating industry is comprised of approximately 109 plants containing 147 coating lines that engage in the application of organic coatings to flat metal sheet or strip that is packaged in rolls or coils. Estimated North American shipments of coated metal coil reached nearly 3.63 million Mg (4 million tons) in 1977, representing a total product value of $3.5 billion.[1] Major markets for coil coated metal include the transportation industry, the building products industry, and the packaging industry. New end uses for the product are constantly emerging, and the industry is expected to maintain a 12 percent rate of growth through 1985.

Types of metal processed by the industry are mainly cold-rolled steel, galvanized steel, and aluminum but also include small amounts of zinc, brass, and copper. The metal is fabricated into end products after it is coated, thus eliminating the need for postassembly painting.

Toll and captive coaters represent the two basic industry divisions. Toll coaters produce metal that is coated in accordance with the specifications of their multiple customers. Captive coaters both coat the metal and fabricate it into end products within the same company. Some plants perform both toll and captive operations.

3.2 COIL COATING PROCESSES AND EMISSIONS

The coil coating process begins with a coil (or roll) of bare sheet metal and terminates with a coil of metal with a dried and cured organic coating on one or both sides. Although the physical configuration of the equipment used in coil coating varies from one installation to another, the individual operations generally follow a set pattern. The metal strip is unrolled from the coil at the entry to the coil coating line and first passes through a wet section, where the metal is thoroughly cleaned and given a chemical treatment (conversion coating) to promote adhesion of the coating to the metal surface. In some installations, the wet section may also contain an electrogalvanizing operation in which a protective zinc coating is applied to steel by an electrocoating process. After the metal strip leaves the wet section, it is squeegeed and air dried and then passes to a coating applicator station. At this point, a coating is applied with rollers to one or both sides of the metal strip. The strip then passes through an oven where the temperature is increased to the desired curing temperature of the coating. The strip is then quenched or cooled (usually by a water spray) and dried. If the line is a "tandem" line, the first coating application is a prime coat, and the metal strip next enters another coating applicator station where a top or finish coating is applied by rollers to one or both sides of the metal. The strip then enters a second oven for drying and curing of the top or finish coat. This is followed by a second cooling (or quench) station. The finished metal is then rewound into a coil and packaged for shipment or further processing. Most coil coating lines have accumulators at the entry and exit that permit the strip to move continuously through the coating process while a new coil is mounted at the entry or a full coil removed at the exit. Figure 3-1 is a schematic diagram of a coil coating line.

For existing coil coating lines, the widths of the metal strip vary from a few to 183 cm (72 in.), and thicknesses vary from approximately 0.018 to 0.229 cm (0.007 to 0.090 in.). The speed at which the metal strip is processed is as high as 3.556 m/s (700 ft/min) on some of the newer lines.

The types of coating applied in coil coating operations include a wide variety of formulations. Among the more prevalent types are polyesters, acrylics, fluorocarbons, alkyds, vinyls, and plastisols. Table 3-1 lists the coatings commonly used by the industry and gives the range of organic solvent content normally present in each coating. As can be seen from Table 3-1, most of the coatings contain organic solvents, which are the major source of volatile organic compound (VOC) air emissions in the industry. The majority of the coatings (estimated to be 85 percent) are organic solvent based and have solvent contents of from 0 to 80 percent by volume, with 40 to 60 percent being the more prevalent range. A smaller fraction of coatings (estimated to be 15 percent) is of the waterborne type, but

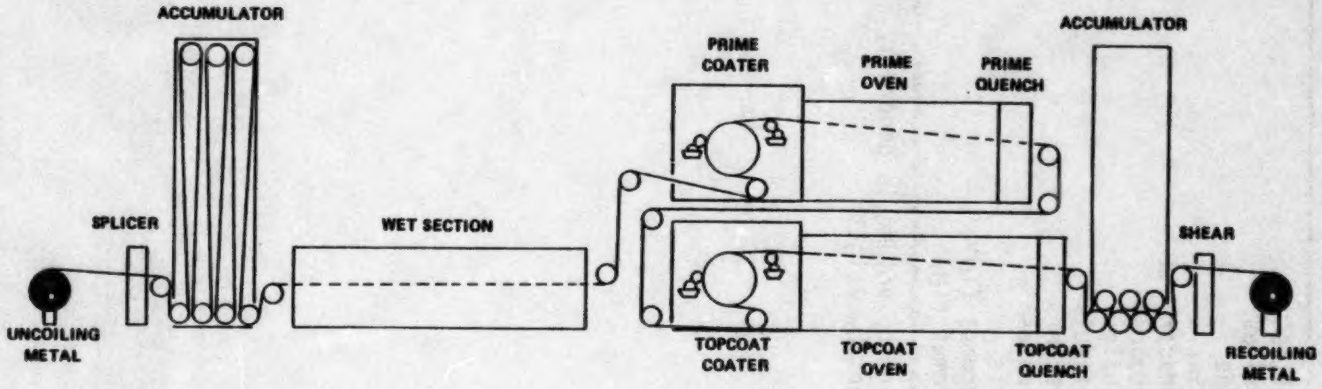
ACCUMULATOR
SPLICER
UNCOILING METAL
WET SECTION
PRIME COATER
PRIME OVEN
PRIME QUENCH
ACCUMULATOR
SHEAR
TOPCOAT COATER
TOPCOAT OVEN
TOPCOAT QUENCH
RECOILING METAL

Figure 3-1. Schematic diagram of a coil coating line.

TABLE 3-1. COATINGS USED IN COIL COATING[2]

Coatings	Volatile content, weight percent[a]
Acrylics	40-45
Adhesives	70-80
Alkyds	50-70
Epoxies	45-70
Fluorocarbons	55-60
Organosols	15-45
Phenolics	50-75
Plastisols	5-30
Polyesters	45-50
Silicones	35-50
Vinyls	60-75
Zincromet (TM)	35-40
Dacromet (TM)	-

[a] The volatile content by volume is generally 5 to 10 percent greater than the volatile content by weight.

these coatings also contain some organic solvent, usually in the range of 2 to 15 percent by volume. The waterborne coatings generally produce a lower mass of VOC emissions per unit of coating solids applied, but waterborne coatings have not as yet been developed for all end-product uses. The choice of a solvent-borne versus a waterborne coating is generally dependent upon the end use of the coated metal and the type of metal used. The most prevalent use of waterbornes is on aluminum used for siding in the construction industry.

High-solids coatings in the form of plastisols and organosols are also used to some extent by the coil coating industry. Because these coatings have a low organic solvent content, VOC emissions from them are lower than those from the more commonly used coatings. Organosols and plastisols are used to coat residential siding, drapery hardware, and other products.

The major sources of VOC emissions in a coil coating plant are the curing ovens. When the metal strip, wet with the freshly applied coating, enters the oven, it passes through several zones that normally operate at successively higher temperatures. During this passage through the oven, the solvent contained in the coating is evaporated, and the metal is heated to a design peak temperature to achieve proper curing of the coating. Most curing ovens are direct fired and use natural gas as fuel. Many ovens are designed to use propane as a backup fuel in case of natural gas curtailments. Ovens heated by fuel oil or electricity are used in some plants, but to a much lesser extent than those heated by natural gas. The heat input to the ovens must be sufficient to evaporate the solvent in the coatings, to bring the metal and coatings up to the design temperature (usually in the range of 191 to 260° C [375 to 500° F]), to replace the heat lost from the ovens by radiation and conduction, and to heat the air used for dilution to the operating temperature of the oven. This latter heat load (i.e., the heating of the oven ventilating air) is normally the largest single factor in the total oven heat load. When solvent is evaporated in an oven, it is necessary to keep the concentration of solvent in the oven atmosphere below the levels at which combustion can occur. The level at which sustained combustion can occur is referred to as the lower explosive limit (LEL).

To ensure that an oven atmosphere is reasonably safe from fires and explosions, dilution air is normally passed through the oven in sufficient quantities to maintain the solvent concentration at or below 25 percent of the LEL. Although the LEL concentration is different for different types of solvents, a value of 283.2 m^3 (10,000 ft^3) of dilution air per gallon of solvent evaporated is usually considered for design purposes to be sufficient to maintain a safe oven atmosphere. In normal operations of an uncontrolled coil coating line, this amount of hot, solvent-laden air is exhausted to the atmosphere, and an equivalent amount of fresh air at ambient temperature is drawn into the oven from the surrounding plant environment. The heating of this volume of dilution air to oven operating temperatures, which may range from 316 to 427° C (600 to 800° F), requires a large quantity of heat. For example, 139 million joules (J), or 131 thousand Btu, are required to heat the dilution air for one gallon of solvent from 21 to 427° C (70 to 800° F). Many coil coaters are now reducing their overall energy consumption by employing techniques to recover and use a portion of the heat that would otherwise be exhausted to the atmosphere.

When waterborne coatings are used, a portion of the coating that must be evaporated in the ovens is water. Because water has a higher heat of vaporization than organic solvents, the heat needed to evaporate the water is greater than would be needed to evaporate an equivalent quantity of solvent. However, because waterborne coatings normally contain only a small volume fraction of solvent, the amount of dilution air required to maintain a safe level of solvent in the ovens when waterborne coatings are used is usually lower than the dilution air required when solvent-borne coatings are used. Consequently, the total heat load of an oven when waterborne coatings are used may be less than the total heat load when solvent-borne coatings are used. However, it has been demonstrated that, with heat recovery systems, solvent-borne coatings require less energy input than waterborne systems. Historically, waterborne coatings have been more expensive than equivalent solvent-borne types; however, this price differential has decreased in recent years, because of increases in solvent costs, and waterbornes are currently priced competitively with the solvent-borne coatings.[3]

It has been estimated that approximately 90 percent of the total solvent content of the coatings used by the industry is evaporated in the curing ovens.[2] Of the remaining 10 percent, it is estimated that 8 percent evaporates at the applicator station and 2 percent at the quench station. In a study of the coil coating industry conducted by Scott Research Laboratories,[4] measurements were made on two coil coating lines of the nonmethane hydrocarbon emissions from the coater room, the ovens, and the quench area. For one line, the percentages of total emissions that were measured from each area were 11 percent, 86 percent, and 3 percent, respectively. For the other line, the corresponding measured percentages were 0.7 percent, 99 percent, and 0.3 percent, respectively. In a test conducted by Clayton Environmental Consultants for Kaiser Aluminum and Chemical Corporation, the emissions from the coating area accounted for 17 percent of total emissions.[5] Based on these data, emissions from the coating area appear to vary substantially from one installation to another. These variations are probably related to the volatility of the coating solvents and other process parameters.

In most new plants, the applicator stations are enclosed in rooms.[6] Because air is drawn into the ovens from these rooms, it is generally postulated that most (and possibly all) of the solvent that evaporates in this area is drawn into the ovens. On lines that do not have coating rooms, an exhaust hood is normally installed directly over the roll coaters to exhaust the solvent that evaporates in that area. The quench stations are also usually contained inside an enclosure adjacent to the exit end of the ovens. Most of the solvent that evaporates in the quench area is also generally believed to be drawn into the oven along with the dilution air.

The actual rate of VOC emissions from a coil coating line is determined by the operating parameters of the line. These parameters include (1) the width of the metal strip, (2) the solvent content of the coating, (3) the speed at which the strip is processed, and (4) the thickness at which the coating is applied. For example, a line processing a strip that is 30.48 cm (12 in.) wide at a speed of 1.778 m/s (350 ft/min) using coatings that are 50 percent solvent by volume and applied at a dry thickness of 0.0254 mm (0.001 in.) on the front side and 0.0203 mm (0.0008 in.) on the back side would emit 89 ℓ (24 gal) of solvent per hour. A line processing a strip that is 167.6 cm (66 in.) wide at a rate of 3.048 m/s (600 ft/min) and using the same coating and coating thickness as above would emit 841 L (222 gal) of solvent per hour. This illustrates the magnitude of the variations that commonly exist in the VOC emissions from individual coil coating lines.

3.3 BASELINE EMISSIONS

The costs directly attributable to a New Source Performance Standard (NSPS) are computed as the difference in the costs of complying with existing regulations and the costs of complying with the NSPS. For these costs to be computed, it is necessary to establish a baseline level of control required by existing regulations. The recommended procedure for establishing this baseline level of control is to compute the average level of control required by existing State regulations. The following discussion is aimed at establishing these average or baseline levels of control that are required in the coil coating industry.

Coil coating plants are dispersed throughout 27 States. Of 109 specifically identified plants, a total of 77 are located in States or major metropolitan air quality control regions (AQCRs) that apply specific numerical limitations to organic solvent emissions. These regulations typically require that organic solvent emissions from paint-baking ovens not exceed 3 lb/h, or a total of 15 lb/day, unless uncontrolled emissions are reduced by 85 percent prior to discharge. For the purpose of computing baseline emissions, it is assumed that all plants in these States are currently subject to a requirement to reduce their emissions by 85 percent prior to discharge. The remaining 32 plants are located in States that use a permit system for controlling emissions. Most of the State Implementation Plans (SIPs) for these States indicate that the degree of control required will be determined on a case-by-case basis. It has not been possible during this study to determine the degree of control that is required in these States. It was, therefore, necessary to make an assumption regarding the degree of control that would be required for new plants locating in these States. EPA has prepared a series of documents, called Control Technique Guidelines (CTGs), to provide guidance to the States in the development of their SIPs. The CTG for coil coating[2] suggests an emission limitation of

0.31 kg VOC/ℓ (2.6 lb VOC/gal) of coating, less water, stated in terms of the solvent content of the coating at the point of application. For the purpose of estimating baseline emissions for plants in those States that now use the permit system, it was assumed that control to at least this recommended level would be required.

Two separate baselines were selected for use in this study because the two different requirements in existing SIPs are reasonably well defined and are significantly different from one another. The SIPs for States that operate under a permit system usually contain provisions that prohibit the violation of ambient air quality standards for hydrocarbons and oxidants. Estimating the degree of control that would be imposed on a coil coating plant by such a provision would be a monumental task. Because the States are in the process of revising their SIPs and have the CTG documents as guidance, it was assumed that the States would incorporate provisions that are at least as stringent as the CTG recommendation. Those States that already have numerical limits on VOC emissions are unlikely to relax these limits in order to conform to the CTG recommendations but would continue to require the more stringent level of control already contained in their SIPs. On the basis of this reasoning, this study uses two baselines from which costs and environmental and economic impacts are computed.

Other information used in estimating baseline emissions includes the following items:

- The annual (1977) production of coil coated metal is $1.2(10^9)$ m^2 [$13(10^9)$ ft^2].[1]
- The annual (1977) usage of coatings by the industry is $72(10^6)$ ℓ [$19(10^6)$ gal].[1]
- Approximately 15 percent of the annual production of the coil coating industry is done using waterborne coatings.[7]
- The average VOC content of waterborne coatings used by the industry is 10 percent by volume.
- The average solids content of all coatings used by the industry is 40 percent by volume.
- The average density of coating solvents is 0.88 kg/ℓ (7.36 lb/gal).

On the basis of the estimated average solvent content of the solvent-borne coatings used by the coil coating industry (i.e., 60 percent by volume) and the estimated annual production and coating usage, the uncontrolled or potential emissions when solvent-borne coatings are used are 0.032 kg/m^2 (0.0065 lb/ft^2) of metal processed. When waterborne coatings are used, average uncontrolled emissions are 0.0054 kg/m^2 (0.0011 lb/ft^2). In areas where emissions are subject to a numerical limit, the actual, or baseline, emissions when solvent-borne coatings are used are 0.0048 kg/m^2 (0.0010 lb/ft^2). This level of emissions reflects an 85 percent reduction from the uncontrolled level. Baseline emissions from waterborne coatings are assumed to be equal to their uncontrolled levels because most SIPs exempt users of waterborne coatings from the reduction requirements.

In areas not subject to a numerical limit, it is assumed that emissions will be controlled to the level of the CTG recommendation of 0.31 kg VOC/ℓ (2.6 lb VOC/gal) of coating as applied (less water), or equivalent. This is equivalent to an emission rate of 0.465 kg/ℓ (4.0 lb/gal) of coating solids applied. Again, if it is assumed that the average coating formulation used by the industry has a VOC content of 60 percent by volume, the uncontrolled, or potential, emissions are 1.279 kg/ℓ (11 lb/gal) of solids applied. To reduce these emissions to the recommended level of 0.465 kg/ℓ (4.0 lb/gal) of solids, a control efficiency of 64 percent would be required. Baseline emissions for plants subject to this limitation would, therefore, be 0.012 kg/m^2 (0.0023 lb/ft^2) of metal processed. For a plant that uses waterborne coatings, baseline emissions would be 0.22 kg/ℓ (1.84 lb/gal) of coating solids for the coating formulation defined above.

Each of the above baseline levels of control will be given consideration in later chapters of this document that describe the environmental and cost impacts of the NSPS.

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4. EMISSION CONTROL TECHNIQUES

4.1 INTRODUCTION

There are two strategies by which volatile organic compound (VOC) emissions from coil coating operations may be reduced. One is to reduce the amount of solvent in the coatings used by the industry, and the other is to remove the VOCs from the exhaust gas streams through the use of add-on control equipment.

The coatings that this industry applies to metal coil surfaces can be divided into two general classes: waterborne coatings and solvent-borne coatings. Approximately 85 percent of coil coating is done with solvent-borne coatings[1] [2] that average 40 percent solids and 60 percent organic solvents by volume. Waterborne coatings also contain organic solvents to aid in wetting the pigments, to produce solubility (in the case of partially water-soluble, film-forming components), and to promote good flow and viscosity characteristics in the coating mixtures. The solvent content of waterborne compositions varies between 2 and 15 percent of the total volume of the coating formulation.

Estimates by the National Coil Coaters Association (NCCA)[3] indicate that approximately 72 million ℓ (19 million gal) of coatings are used each year in this industry. This volume includes approximately 37.7 million ℓ (9.97 million gal) of solvent, all of which represents potential atmospheric emissions totalling 33.3 Gg (36,690 tons) per year. Since there are reportedly 146 coating lines in operation, this is an average emission potential of 227 Mg (251 tons) per year per line.

4.2 DESCRIPTION OF INDUSTRY CONTROL TECHNIQUES

Commonly used add-on control equipment for the removal of volatile organic emissions from industrial operations include adsorbers, incinerators, condensers, and absorbers. During the drying, or curing, process used in coil coating, a mixture of organic vapors and air is exhausted from the ovens at temperatures of 260 to 426° C (500 to 800° F), which present major problems to the use of adsorption, condensation, and absorption as methods of controlling VOC emissions. For removing organics from the exit streams, therefore, the coil coating industry has almost exclusively chosen incineration. Two methods of incineration are available: thermal and catalytic. The majority of incineration units used for control in this industry are thermal units.

It should be noted that equipment for controlling organic emissions through the use of afterburners (incinerators) that exhaust directly to the atmosphere is expensive to install and results in significant increases in fuel consumption. As fuel costs have increased rapidly in recent years, equipment vendors have developed energy recovery systems that are combined with incinerators to recover a major portion of the heat from the exhaust gases and to use the flammable solvent vapors from the coatings as fuel.

4.2.1 Thermal Incineration

Thermal incinerators consist of an oxidation chamber and a burner. The waste gas stream is introduced into the incinerator where proper conditions of time, temperature, and turbulence are achieved to oxidize the solvent in the gas stream. Most solvents will oxidize with about 90 percent conversion efficiency if a temperature of 650° C (1,200° F) and a residence time of 0.3 to 0.5 s is achieved. To achieve conversion efficiencies of greater than 90 percent, incinerators are normally operated at temperatures of 760 to 815° C (1,400 to 1,500° F).[4] Available emission test data for thermal incinerators indicate conversion efficiencies ranging from 87.6 to 99.6 percent. A summary of these data is given in Table 4-1.

The heating of the exhaust stream to the high incineration temperatures requires large amounts of energy unless some means of heat recovery is incorporated into the system. Many recent installations of thermal incinerators in the coil coating industry have included a means of heat recovery to reduce the energy consumption of the systems. Several concepts of heat recovery are in successful operation in the industry. These include direct recycle of a portion of the oven atmosphere through internal oven burners or incinerators, the use of regenerative heat exchangers, and the use of recuperative heat exchangers. Waste heat boilers are also employed in conjunction with some of the systems. Steam from these boilers can be used in the wet section of the coil coating line or in other processes in the

TABLE 4-1. EMISSION TEST RESULTS FOR THERMAL INCINERATORS ON COIL COATING LINES

Unit sampled	Total VOC concentration Uncontrolled, inlet	Controlled	Percent conversion	Temperature °C	(°F)
Precoat Metals					
Finish	16,588	1,228	92.6	760	1,400
Prime	5,759	271	95.3	760	1,400
	6,857	270	96.1	760	1,400
	6,975	298	95.7	760	1,400
Scott Research Laboratory tests					
Unit 031	7,320 ppmv	33 ppmv	99.5	760	1,400[a]
Unit 033	7,155 ppmv	800 ppmv	88.8	649	1,200[a]
Kaiser Aluminum	4,530 ppmv	560 ppmv	87.6	704	1,300
SupraCote Corp.[b] zone incinerators					
Finish (average of 5 incinerators	3,718 ppmv	32 ppmv	99.1	768	1,414
Prime (average of 4 incinerators	733 ppmv	55 ppmv	92.5	717	1,323
INRYCO					
Average	552 ppmv[c]	29 ppmv[c]	94.8	704	1,300
Metal Koting					
Average	8,100 ppmv	109 ppmv	98.7	871	1,600
Roll Coater					
Prime	210 lb/h	.005 lb/h	99.9	649	1,200
Finish	492 lb/h	1.07 lb/h	99.8	482	900
	492 lb/h	1.28 lb/h	99.9	543	1,100
	492 lb/h	.002 lb/h	99.9	649	1,200

[a] Estimated.

[b] System no longer in operation.

[c] Measured as propane.

plant. The use of heat recovery has no detrimental effect on the efficiency with which the incinerator removes VOCs from the exhaust gas stream. The following paragraphs describe several of the thermal incineration and heat recovery systems that are currently in use in the coil coating industry.

4.2.1.1 Zone Incineration. The ovens on coil coating lines are generally divided into zones. Each zone is equipped with a burner, and each succeeding zone is normally maintained at a higher temperature than the previous one. For example, a four-zone oven for a finish coat might have a temperature gradient of 315, 343, 371, and 399° C (600, 650, 700, and 750° F) in the four zones. In the zone incineration system, the normal burner in each oven zone is replaced by an incinerator through which a mixture of solvent vapor and air drawn from the oven is passed. These gases are incinerated along with enough natural gas to bring the zone temperature to a preset level. The exhaust gases from the incinerator are injected directly into the oven. Approximately 60 percent of the solvent vapor that evaporates in the oven passes through the zone incinerators and is destroyed. The remainder is exhausted directly to the atmosphere or to an afterburner.

Some coil coaters have stated that they can meet existing State air quality regulations using only the zone incinerators without an afterburner.[5] However, it is unlikely that zone incinerators alone would be capable of meeting the standard in States that require an 85 percent reduction in emissions.

Recycling the oven atmosphere through the zone incinerators reduces the amount of air that must be heated from ambient temperature to the temperature of the oven and thus reduces the fuel required for air heating. Substituting solvent vapor for part of the fuel further reduces fuel consumption. Zone incineration coupled with recirculation of the oven atmosphere results in a significant reduction in the volatile organic emissions from the metal coil coating line and results in a considerable reduction in the energy (fuel) necessary to dry (cure) the coating film.

Adding an afterburner to the above system to oxidize the remaining 40 percent of the organic vapors results in a system that will destroy a minimum of 90 percent of the volatile organics that enter the drying (curing) oven.[6] The addition of the afterburner causes an increase in energy consumption and an increase in the cost of control unless the heat generated by the incinerator is recovered. One means of recovering this heat is to install waste heat boilers that use the heat to generate process steam. When the demand for process steam is not great enough to use the amount generated, other forms of heat recovery may be employed (for example, preheated oven exhaust, space heating, etc.).

4.2.1.2 Regenerative Heat Recovery. A second system of incineration and heat recovery that is suitable for coil coating installations uses a heat sink. This heat sink is alternately used (1) to add heat to the oven exhaust gas to raise the temperature to or near the point necessary for thermal oxidation in a gas-fired incinerator and (2) to extract heat from the incinerator exhaust to reduce the temperature of the gas before it is returned to the ovens, exhausted to the atmosphere, or used for additional heat recovery.

Solvent vapors, air, and products of combustion are exhausted from the ovens, mixed, and transported (by means of an exhaust fan) to a heat sink, where the gas temperature is raised through the absorption of heat from the heat sink. The gases then pass to an incinerator operating at a temperature of about 815° C (1,500° F). The products of combustion exit from the incinerator through the heat sink, where heat is imparted to the heat sink. Part of these cooled gases is returned to the ovens to serve as the heat source. The remainder of the gases may be exhausted to the atmosphere or may be passed through a heat exchanger or a waste heat boiler for additional heat recovery. A minimum of two heat sinks is required in these systems, and as many as seven have been reported in a single installation. The heat sinks are generally packed with ceramic material that alternately absorbs and releases heat energy.

A disadvantage of this system is the large space requirements for installation of the heat sinks and combustion chamber units and their associated ducting. This disadvantage applies primarily to retrofit installations since new plants can be designed to accommodate the system.

4.2.1.3 Recuperative Heat Recovery. A third system of heat recovery is the use of recuperative heat exchangers. This system is very similar to the regenerative heat exchanger but uses an air-to-air heat exchanger instead of the packed beds. In this system, the oven exhaust gas stream passes through the heat exchanger before entering the incinerator. The oven exhaust gas stream is heated by the hot exhaust gas leaving the incinerator. After incineration, the hot exhaust gases pass through the heat exchanger and give up heat to the gas stream entering the incinerator. After they are cooled, the incinerator exhaust gases may be exhausted to the atmosphere, passed through additional heat exchangers, or returned to the oven to supply heat. The amount of heat that can be recovered in the recuperative heat exchanger is limited by the autoignition temperature of the oven exhaust gases.

4.2.1.4 Direct Recycle Heat Recovery. A fourth heat recovery option is the direct recycle of incinerator exhaust to the ovens. This technique is sometimes employed in conjunction with regenerative of recuperative heat exchangers, as described in preceding paragraphs, or it may be used alone. One unique direct recycle system is the low-oxygen system. In this system, the solvent-rich gases from the oven are exhausted to a single afterburner, where the solvent vapors are incinerated along with enough natural gas to maintain a preset temperature. Only the stoichiometric requirement for air is introduced into the incinerator so that the exhaust from the incinerator has an oxygen content in the range of 2 to 3 percent. Most of these exhaust gases are returned to the oven to supply the heat necessary to cure the coatings. A small volume of the incinerator exhaust is ducted to the atmosphere. This volume is equal to the volume of stoichiometric air and natural gas introduced into the incinerator. The entire system is maintained as a closed loop by the use of air seals at the oven openings. The oxygen content of the oven atmosphere is maintained below the level required for combustion of the solvent vapors, thus eliminating the need for large quantities of dilution air. Fuel savings result from burning solvent vapors in combination with natural gas, supplying oven heat with the recycled products of combustion, and reducing the volume of dilution air that must be heated to oven temperature. A report on one such system that is currently in operation states that the gases exhausted to the atmosphere have a VOC content of less than 50 ppm and that fuel savings that result from the system are in the range of 55 to 82 percent.[7]

4.2.2 Catalytic Incineration

Catalytic incinerators operate on the same basic principles as thermal incinerators but contain a catalyst. The catalyst causes the oxidation reaction between the solvent and air to occur at a lower temperature for the same solvent concentration and composition. Therefore, catalytic units require less fuel to heat the oven exhaust gases to combustion temperatures, and they have a lower exhaust temperature than equivalent thermal incinerators.

Installation costs for catalytic incinerators are comparable to those of thermal oxidation units, but catalytic incinerators are generally smaller than equivalent thermal systems, resulting in a space savings over a thermal system. These savings are offset by the cost of the catalysts, which are noble metals or metal oxides. The most commonly used catalyst is platinum and its salts.

In some situations, problems may be encountered with the use of catalytic incineration systems. The major problem is catalyst deactivation. Catalysts are deactivated (poisoned) when they are contacted by elements such as lead, antimony, cadmium, zinc, phosphorus, arsenic, and copper. Some of these elements are present in the pigment component of coil coatings. In addition, the catalyst may be masked by high molecular weight organics, alumina, and silica dusts and may be suppressed by halogens and sulfur, each of which is present in some coating formulations.

When a catalyst becomes deactivated (poisoned) or masked, it must be regenerated or cleaned. The time necessary for the cleaning-regeneration can vary from a few hours to a day.

The members of the industry that have found catalytic incineration suitable for their situations are the captive coaters that coat only a few different products with a limited number of coatings. These coaters can control the coating materials used to insure that no chemical poisons are present to deactivate the catalysts. However, for toll coaters, who must often use a wide variety of coatings specified by their customers, the chance of catalyst poisons being introduced into the catalytic incineration system is proportionately greater.

One coil coater stated that he plans to install a catalytic incinerator and will include a filter in the gas stream ahead of the catalyst to remove impurities that might poison or mask the catalyst.[9] He further stated that his company has installed a similar system on a can coating operation. That system is reportedly operating satisfactorily.

For the forseeable future, catalytic incineration will probably be limited to captive coaters, who have greater control over the coatings used. Thermal incineration with heat recovery may continue to be the more appropriate system for coaters who use many different coating formulations.

Emission tests on catalytic incinerators were identified for only one installation. In two separate tests, the average conversion efficiency was found to be 92.2 percent and 99.5 percent.[8] The incinerator operating temperature was not reported for the first series of tests. In the second series, measurements were made at incinerator temperatures of 238 and 393° C (460 and 740° F). Although catalytic incinerators are inherently more energy efficient than thermal incinerators, their use is even more efficient if a heat recovery system is added. Any of the heat recovery techniques described above for thermal incinerators can be applied in conjunction with catalytic incinerators.

4.2.3 Coating Rooms

When an emission control device is used to control VOC emissions, the efficiency with which the total emissions are captured and sent to the control device is an important factor in the overall emission reduction that can be achieved. Emission studies indicate that as much as 8 percent of the total VOC input to a coil coating operation may be given off at the coating application station before the metal strip enters the oven. The capture of these coating station emissions, therefore, plays an important part in the overall emission reduction that can be achieved with an emission control device. Many of the coil coating lines that were observed during this background study have the coating application stations enclosed in rooms. The normal design of these rooms has the ventilation supplied from the side of the room opposite the oven. Because a portion of the normal oven ventilation enters the oven through the opening where the metal strip enters, the oven ventilating air flows across the room, over the coating application equipment, and over the wet metal strip before entering the oven. In addition, some of the lines also employ a hood or snout that extends from the oven opening, over the wet metal strip to a point near the coating rolls. Such an arrangement greatly increases the capture of VOC emissions relative to a system that has open coating stations. One coil coating line was identified that passes all of the coating room ventilation through the oven, which should result in very nearly complete capture of the emissions from the coating application station. However, many coaters and vendors of coil coating equipment have stated that the amount of air that enters the oven through the coating room does not adequately ventilate the coating room. Consequently, most coating rooms have a part of their ventilating air exhausted to the atmosphere or to the plant. Even under these conditions, most of the VOC emissions that occur at the coating application station can be captured by the air entering the oven from the coating room if a hood or snout is employed. Statements submitted by industry representatives imply that an overall capture efficiency of 95 percent is achievable under these conditions, and one vendor estimated that a capture efficiency of 98 percent could be achieved.[10] [11] These statements as well as industrial ventilation standards, imply that the overall control efficiency of an emission control system can be greatly improved by the proper use of coating rooms and hooding to improve the overall capture efficiency of the VOC emissions.

4.2.4 Waterborne Coatings

One method of eliminating volatile organic emissions from the metal coil coating process is to reformulate the coatings to exclude VOCs. With this objective in mind, coating manufacturers have been formulating and marketing waterborne coatings for some time.

All waterborne coatings contain some VOCs. These VOCs are necessary in order to produce a coating film with properties comparable to those produced by solvent-borne coatings. The VOCs must be present to ensure wetting of the pigment. Poor wetting results in poor distribution of the pigment in the liquid vehicle and reduces the hiding power and gloss of the coating. VOCs are used to adjust the rate of evaporation of the vehicle, to adjust the viscosity of the coating, and to increase the solubility of the water-soluble, film-forming components of the coating.

As mentioned earlier, it is estimated that approximately 15 percent of all coil coating is currently done with waterborne coatings. Most of the current usage is on aluminum substrates, but a significant quantity is also used on steel substrates.[12] The variety of coatings needed to produce the performance and aesthetic properties for the many products made from coil coated metal are not yet available as waterborne coatings. This is one of the more important reasons why more of the industry has not converted. A representative of one of the major coating manufacturers estimates that the usage of waterborne coatings will continue to increase over the next several years but also estimates that their most important use will continue to be on aluminum building products.[2]

The use of waterborne coatings results in an energy savings in the ovens relative to an uncontrolled line that uses solvent-borne coatings, even though the heat of vaporization for water is much higher than that for organic solvents. The energy savings result from the fact that the amount of dilution air that must be passed through the oven (and heated) is reduced when waterborne coatings are used.[12]

Contacts were made with a number of coating manufacturers to solicit information on the VOC content of waterborne coatings that are used by the coil coating industry. The data submitted by the manufacturers show the VOC content ranging from a low of 0.07 kg/ℓ (0.58 lb/gal) of coating solids to a high of 0.54 kg/ℓ (4.51 lb/gal) of coating solids. This range represents 24 different coating formulations.[13 14 15 16 17] Of these 24 formulations, 20 have a VOC content of 0.28 kg/ℓ (2.34 lb/gal) of coating solids or less.

4.2.5 Other Control Methods

Other emission control techniques that are sometimes used in metal surface coating industries include high-solids coatings, powder coatings, radiation curing, and carbon adsorption. In the coil coating industry, none of these techniques has found widespread use. Some high-solids coatings are used by the industry in specialized, limited-use applications. For example, organosols, with a solids content in the range of 50 to 80 percent by volume, and plastisols, with a solids content of 80 to 95 percent by volume, are occasionally used by the coil coating industry. These coatings are normally used by toll coating plants that also use many other coating formulations with higher solvent content. Additionally, because of the hydrostatic properties of available high-solid coatings, existing equipment often cannot be used to apply the thinner film thicknesses needed for many end products. Consequently, the use of high-solids coatings as the basis for a standard does not appear to be a feasible alternative.

The use of carbon adsorption as a means of controlling VOC emissions from coil coating is dismissed by most knowledgeable individuals as being unacceptably expensive because of the high temperatures of the exhaust gas streams and the questionable value of the recovered solvent.[18] Therefore, this technique has not been widely considered as an option available to the industry, and there are no known installations on coil coating lines.

Powder coatings have not been used commercially in the coil coating industry because of technical problems in application and because of the limited selection available.[19]

Radiation cured coatings are used for a few applications in coil coating. Three small lines are reported to be in operation in the industry, but the variety of coatings available for the process is quite limited, and, to date, radiation cured coatings have been used only for one-coat systems.[20] Estimated VOC emissions from the process are near zero; however, it is not considered to be a feasible control alternative for widespread use because of the limitations cited above.

Electrodeposition (EDP) as a method of applying the prime coat on metal coil is known to be used on one line in the United States.[9] The plant uses a wide variety of top coats with the system and reports that formability and other characteristics of the finished metal are equivalent to most other two-coat systems. In the EDP system, the metal strip is passed through a liquid bath containing coating solids, water, and cosolvents. The solids are electrodeposited on the strip, and the liquid remains in the bath, except for a minute amount that is entrained with the coating solids and the amount that adheres to the surface of the strip when it emerges from the bath. The surface liquid is removed from the strip by a squeegee and returned to the bath, and the coated strip is dry to the touch at that point. The strip then passes to a coating station where a top coat is applied by roll coating. The strip then passes through an oven where both coats are cured in a single pass. Emissions from the EDP coating operation are estimated to be near zero. The organic solvent content of the EDP bath is generally less than 5 percent.[21]

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5. MODIFICATIONS AND RECONSTRUCTION

New Source Performance Standards (NSPS) apply to newly constructed facilities and to existing facilities that undergo modification or reconstruction. Definitions of modification and reconstruction are given in Title 40, Section 60, of the Code of Federal Regulations.[1] Briefly, a modification is defined as any physical or operational change in an existing facility that results in an increase in the emission rate from that facility, and a reconstruction is defined as an expenditure on new components for an existing plant that exceeds 50 percent of the capital cost that would be required to construct a comparable, entirely new facility. This chapter presents a discussion of modifications and reconstruction as they relate to the NSPS for the coil coating industry.

5.1 DESCRIPTIONS OF TYPICAL MODIFICATIONS AND RECONSTRUCTION

The subject of modifications to and reconstruction of coil coating lines was discussed with a number of industry representatives during plant visits and through telephone calls. On the basis of these discussions, a conclusion was reached that most modifications to coil coating lines are made either to increase the processing rate or to reduce the energy consumption of the line. Those modifications that are made to increase processing rate (or line speed) result in an increase in emissions and therefore would make the line subject to the requirements of an NSPS. Modifications to increase line speed are often accomplished by replacing the drive motors, by changing the electrical controls on the line, or by both.[2] [3] In many cases, significant increases can be made in line speed without modifications to the ovens, either because the original ovens were constructed with excess capacity or because improvements in coating technology have resulted in improved coating curing performance. In other cases, oven modifications may be required in order to increase line speed. At least one plant is planning to incorporate a curing booster on the ovens of one coil coating line so as to increase line speed.[4]

Modifications to coil coating lines for the purpose of improving the energy efficiency of the line do not cause the line to become subject to the requirements of an NSPS because such modifications do not cause an increase in emissions. In most cases, modifications of this type decrease emissions by recycling a portion of the oven exhausts through the oven burners[2] or by adding an incinerator with heat recovery.[5] For both types of modifications, the capital investment required is $100,000 or less. Therefore, they cannot be classified as reconstructions, and the facility becomes subject to the NSPS only when an increase in emission rate results.

Only a few reconstructions of coil coating lines were identified during this study. In some cases a line reconstruction is implemented to convert a single-coat line to a tandem line,[6] and, in one instance, a line was reconstructed to change from vertical to horizontal ovens and from a horizontal to a vertical wet section.[6] These types of activities require a capital investment approaching 50 percent of the cost of a new line and could make a facility subject to the NSPS from that standpoint.

5.2 RETROFIT CONSIDERATIONS

When coil coating lines are modified to increase the line speed, VOC emissions increase in direct proportion to the increase in speed if other operating parameters remain unchanged. These types of modifications will probably continue to be implemented on the older, slower lines as the demand for additional capacity expands over the next few years. These modifications could lead to an increase in VOC emissions in proportion to the increase in plant capacity that is developed by the modifications unless emission controls are installed on the modified lines.

All of the control techniques discussed in Chapter 4 are adaptable to existing lines that undergo a modification or reconstruction. The use of each of the control techniques as a retrofit on existing lines is well documented in the literature. As a result, no major problems are anticipated in applying retrofit controls on coil coating lines that undergo modifications or reconstructions. The installation cost of an emission control system as a retrofit is normally somewhat higher than the cost of a new installation; however, this cost increment does not appear to be a major consideration, as discussed in Chapter 8.

5.3 REFERENCES

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6. MODEL PLANTS AND REGULATORY ALTERNATIVES

This chapter provides information describing model plants and regulatory alternatives in the metal coil surface coating industry. These model plants are representative of new plants that are expected to be built by the industry in the near future. The model plant parameters given are based on information obtained during visits to eight coil coating plants, on information obtained from literature and industry sources, and from State and Federal governmental regulatory agencies involved in pollution control. The model plants and regulatory alternatives presented here were developed for the purpose of estimating the environmental, economic, and energy impacts of a New Source Performance Standard (NSPS) for the coil coating industry.

6.1 MODEL PLANTS

Plants that would be affected by an NSPS include all new plants and all existing plants that undergo modification or reconstruction. Specific operations in a coil coating plant that would be covered by a standard include the application and curing of the coating on the metal strip. A typical coil coating operation consists of an uncoiler station, a splicer, an inlet accumulator, a wet section (cleaning, treating, and rinsing), a prime coat applicator, a prime coat curing oven, a quench station, a finish or top coat applicator, a finish coat curing oven, a quench station, an exit accumulator, a shear, and a recoil station. Some lines also have printing and laminating capabilities. A schematic diagram of a typical coil coating line is given in Figure 6-1.

Information pertaining to the operating conditions of existing coil coating plants was used to define the size ranges to be considered for the model plants. This information was obtained from several sources, including the National Coil Coaters Association (NCCA), industry personnel, and a literature review. However, the most comprehensive data for this purpose

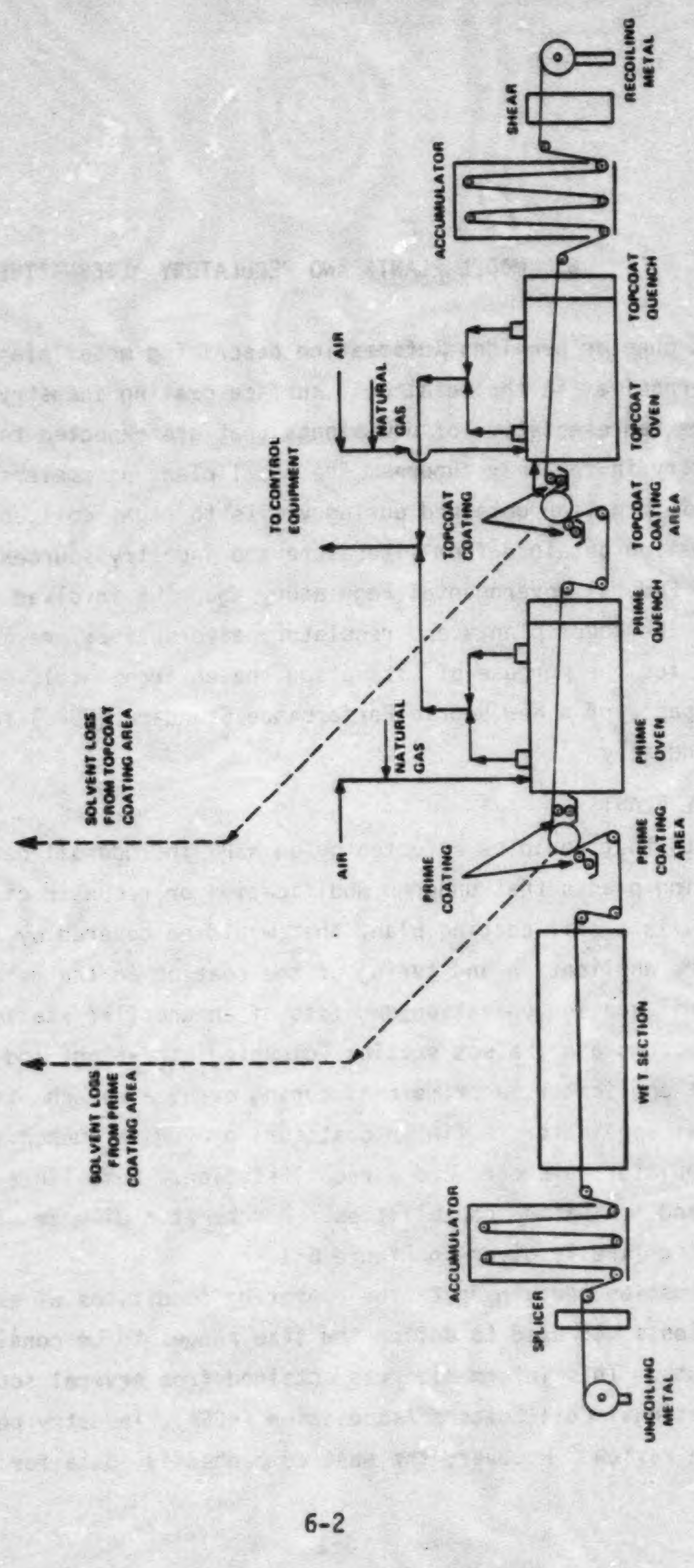
UNCOILING METAL
SPLICER
ACCUMULATOR
SOLVENT LOSS FROM PRIME COATING AREA
WET SECTION
PRIME COATING
AIR
PRIME COATING AREA
SOLVENT LOSS FROM TOPCOAT COATING AREA
NATURAL GAS
PRIME OVEN
PRIME QUENCH
TOPCOAT COATING
TO CONTROL EQUIPMENT
TOPCOAT COATING AREA
NATURAL GAS
AIR
TOPCOAT OVEN
TOPCOAT QUENCH
ACCUMULATOR
SHEAR
RECOILING METAL

Figure 6-1. Schematic diagram of model coil coating line.

were obtained from the Effluent Guidelines Division (EGD) of EPA. EGD had recently completed a survey of the coil coating industry as a part of its activities in developing regulations governing liquid effluent from coil coating operations. Information gathered during this survey included line speeds and widths, annual production, number of employees, and other items of interest to the current study. Data from this survey were used to establish the size ranges for small, medium, and large coil coating plants. These general size ranges are discussed below; a description of the specific model plants then follows. All of the model plants consist of a single coil coating line. In reality, plants often operate more than one coil coating line.

A small plant is estimated to have an annual production of approximately 4.6 million m^2 (50 million ft^2) of metal. Such a plant may operate coil coating lines capable of processing metal in widths of 0.46 m (18 in.) or less at line speeds up to 1.78 m/s (350 ft/min). The maximum solvent capacity of the ovens in such a plant would be about 0.032 ℓ/s (30 gal/h). Annual operating hours may range from 3,000 to 6,000.

A medium size plant is estimated to have an annual production of 14 million m^2 (150 million ft^2) of metal. Such a plant may operate coil coating lines with the capability of coating metal strip up to 1.22 m (48 in.) wide at line speeds up to 2.03 m/s (400 ft/min). Maximum oven solvent capacity for these lines would be about 0.095 ℓ/s (90 gal/h). Annual operating hours may range from 3,000 to 6,000.

A large coil coating plant is estimated to have an annual production of 28 million m^2 (300 million ft^2) of metal. A plant of this size may operate coating lines capable of processing metal in widths up to 1.83 m (72 in.) at speeds as high as 3.56 m/s (700 ft/min). Maximum solvent capacity of the ovens on these lines would be about 0.210 ℓ/s (200 gal/h). Annual operating hours may range from 3,000 to 6,000.

Information obtained during several plant visits indicates that coating is actually being applied during approximately 70 percent of the plant operating hours. The remaining time is spent performing maintenance and making color changes. These figures, along with the plant size ranges given above, were used to develop the three model plants. Parameters for these plants are listed in Figures 6-2, 6-3, and 6-4.

Annual operating time: 4,000 h

Annual coating time: 2,780 h

Total metal processed: 4.6×10^6 m^2/yr (50×10^6 ft^2/yr)

Metal: Aluminum, 0.46 m (18 in.) wide
0.30 mm (0.012 in.) thick

Line speed: 1.02 m/s (200 ft/min)

Coating: Solvent based, with 60 percent by volume solvent (toluene)
Total dry film thickness, prime coat, 0.0114 mm (0.00045 in.) each side
Total dry film thickness, top coat, 0.0114 mm (0.00045 in.) each side

Ovens:

Number	2
Maximum solvent input[a]	0.32 ℓ/s (30 gal/h) each oven
Average solvent input	0.16 ℓ/s (15.1 gal/h) each oven
Air flow[b]	2.4 m^3/s (5,000 SCFM) each oven
Exhaust temperature	316° C (600° F)

Uncontrolled emissions: 275 Mg/yr (303 ton/yr)

Baseline emissions:
States using numerical limits: 41.2 Mg/yr (45.4 ton/yr)
States using CTG limits: 99.0 Mg/yr (109 ton/yr)

[a] Solvent rates are given per unit of actual coating time.

[b] Air flow rate is given at standard conditions of 15.6° C (60° F) and 101 kPa (14.7 psia).

Figure 6-2. List of model plant parameters for small plant with 1 coating line.

Annual operating time: 4,000 h

Annual coating time: 2,780 h

Total metal processed: 14×10^6 m^2/yr (150×10^6 ft^2/yr)

Metal: Steel, 0.91 m (36 in.) wide
0.43 mm (0.017 in.) thick

Line speed: 1.5 m/s (300 ft/m)

Coating: Solvent based, with 60 percent by volume solvent (toluene)
Total dry film thickness, prime coat, 0.0114 mm (0.00045 in.) each side
Total dry film thickness, top coat, 0.0114 mm (0.00045 in.) each side

Ovens:

Number	2
Maximum solvent input[a]	0.095 ℓ/s (90 gal/h) each oven
Average solvent input	0.048 ℓ/s (45.4 gal/h) each oven
Air flow[b]	7.1 m^3/s (15,000 SCFM) each oven
Exhaust temperature	316° C (600° F)

Uncontrolled emissions: 828 Mg/yr (912 ton/yr)

Baseline emissions:

States using numerical limits: 124 Mg/yr (137 ton/yr)
States using CTG limits: 298 Mg/yr (328 ton/yr)

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[a] Solvent rates are given per unit of actual coating time.

[b] Air flow rate is given at standard conditions of 15.6° C (60° F) and 101 kPa (14.7 psia).

Figure 6-3. List of model plant parameters for medium plant with 1 coating line.

Annual operating time: 4,000 h

Annual coating time: 2,500 h

Total metal processed: 28 × 10^6 m^2/yr (300 × 10^6 ft^2/yr)

Metal: Steel, 1.22 m (48 in.) wide
0.48 mm (0.019 in.) thick

Line speed: 2.5 m/s (500 ft/min)

Coating: Solvent based, with 60 percent by volume solvent (toluene)
Total dry film thickness, prime coat, 0.0114 mm (0.00045 in.) each side
Total dry film thickness, top coat, 0.0144 mm (0.00045 in.) each side

Ovens:

Number	2
Maximum solvent input[a]	0.21 ℓ/s (200 gal/h) each oven
Average solvent input	0.11 ℓ/s (101 gal/h) each oven
Air flow[b]	15.6 m^3/s (33,000 SCFM) each oven
Exhaust temperature	316° C (600° F)

Uncontrolled emissions: 1,650 Mg/yr (1,820 ton/yr)

Baseline emissions:

States using numerical limits: 248 Mg/yr (273 ton/yr)
States using CTG limits: 594 Mg/yr (655 ton/yr)

[a] Solvent rates are given per unit of actual coating time.

[b] Air flow rate is given at standard conditions of 15.6° C (60° F) and 101 kPa (14.7 psia).

Figure 6-4. List of model plant parameters for large plant with 1 coating line.

In the small model plant, total annual production is 4,110 Mg/yr (4,080 ton/yr), and uncontrolled or potential emissions are 275 Mg/yr (303 ton/yr). Baseline emissions for States having numerical limits are 41.2 Mg/yr (45.4 ton/yr); for States using Control Technique Guideline (CTG) limits, baseline emissions are 99.0 Mg/yr (109 ton/yr).

In the medium size plant, annual production is 54,800 Mg/yr (60,300 ton/yr), and uncontrolled emissions are 828 Mg/yr (912 ton/yr). Baseline emissions for States having numerical limits are 124.2 Mg/yr (136.8 ton/yr); for States using CTG limits, baseline emissions are 298 Mg/yr (328 ton/yr).

In the large plant, annual production is 104,000 Mg/yr (116,000 ton/yr), and uncontrolled emissions are 1,650 Mg/yr (1,820 ton/yr). Baseline emissions for States having numerical limits are 247.5 Mg/yr (273 ton/yr); for States using CTG limits, baseline emissions are 594 Mg/yr (655 ton/yr).

The annual operating time of 4,000 hours for each plant is the equivalent of 2 shifts per day, 5 days per week, 50 weeks per year. Actual coating times were calculated from industry averages and are 2,780 hours per year for the small and medium size plants and 2,500 hours per year for the large plant.

Water usage of the model lines is estimated using an overall factor of 4.0 ℓ/m^2 obtained from EGD. The water requirements are as follows: small plant, 4,600 ℓ/h (1,200 gal/h); medium plant, 14,000 ℓ/h (3,700 gal/h); and large plant, 28,000 ℓ/h (7,400 gal/h).

The enclosed area of structures housing the model coil coating lines will be approximately 6,690 m^2 (72,000 ft^2) for the small plant, 9,290 m^2 (100,000 ft^2) for the medium plant, and 12,800 m^2 (138,000 ft^2) for the large plant.

6.2 REGULATORY ALTERNATIVES

This section presents a discussion of the regulatory alternatives to be considered for the coil coating industry. The discussion is based on information obtained from industry and literature sources. The impacts on emissions for each regulatory alternative are discussed in Chapter 7 of this document. A set of revised regulatory alternatives is discussed in Appendix E.

The first regulatory alternative to be considered is no additional regulation. Under this alternative, emissions from coil coating plants would continue to be governed by State regulations. There are no compliance costs associated with this alternative. However, as discussed in Chapter 7, the no-regulation alternative also has no positive impact on emissions and may lead to a degradation of the ambient air quality.

A second regulatory alternative is to require that overall emissions be reduced by 85 percent or to limit emissions to the equivalent (on the basis of the coating solids applied) of that obtained by an overall reduction of 85 percent in the emissions from the average industry coating formulation of 40 percent solids and 60 percent organic solvent by volume. A standard based on this alternative would be approximately equal to existing State regulations that have numerical limits on volatile organic compound (VOC) emissions. Compliance with the 85 percent alternative could be achieved by using an incinerator with a 95 percent destruction efficiency in conjunction with 90 percent capture of the total emissions. This capture efficiency is normally achieved without a coating room. Compliance could also be achieved by using a less efficient incinerator and a more efficient capture system. Compliance with a limit based on an 85 percent reduction in the emissions from the average industry coating formulation could be achieved by incineration or by using low-solvent coatings.

A third regulatory alternative is to require that overall emissions be reduced by 95 percent or to limit emissions to the equivalent (on the basis of the coating solids applied) of that obtained by an overall reduction of 95 percent in the emissions from the average coating formulation used by the industry (40 percent solids and 60 percent solvent by volume). Compliance with the 95 percent alternative could be achieved by using an incinerator with a 95 percent destruction efficiency in conjunction with a coating room to insure that 100 percent of the VOC emissions are captured by the ovens. Compliance with a limit based on a 95 percent reduction in the emissions from the industry average coating formulation could be achieved by incineration or by using low-solvent coatings.

Appropriate parameters for incinerators that meet the requirements of the above control alternatives are given in Chapter 8 along with their estimated costs. Costs are presented for both the installation and the operation of the incineration systems.

7. ENVIRONMENTAL IMPACT

This chapter presents a discussion of the environmental impact of each of the regulatory alternatives presented in Chapter 6. The discussion includes the impact of each regulatory alternative on air emissions, water quality, solid waste, and energy. All calculations and conclusions regarding environmental impact are based on the model plants described in Chapter 6 and on the industry growth projections given in Chapter 8.

The regulatory alternatives for which impacts are discussed are as follows:

- No NSPS.
- Reducing overall emissions by 85 percent or limiting emissions to the equivalent of that obtained by an overall reduction of 85 percent in the emissions from the average industry coating formulation of 40 percent solids and 60 percent organic solvent by volume.
- Reducing overall emissions by 95 percent or limiting emissions to the equivalent of that obtained by an overall reduction of 95 percent in the emissions from the average industry coating formulation of 40 percent solids and 60 percent organic solvent by volume.

The impacts of a set of revised regulatory alternatives are presented in Appendix E.

7.1 AIR POLLUTION IMPACT

As discussed in Chapter 8, it is estimated that the coil coating industry is currently operating at approximately 65 percent capacity and that the industry will maintain a growth rate of approximately 12 percent per year over the next several years. Although a portion of this projected growth can be absorbed by existing plant capacity, new plant capacity will be needed to maintain this growth rate over an extended period. This additional capacity can be achieved by increasing the production of existing coil coating lines or by building new lines.

The impact of a promulgated New Source Performance Standard (NSPS) on air emissions of volatile organic compounds (VOCs) is calculated as the difference between the emissions that are permitted by existing regulations and the emissions allowed under the NSPS. Currently there are 21 States or parts of States that have existing regulations that include a specific numerical limit on VOC emissions.[1] These States are listed in Figure 7-1. Although the limits for these States vary somewhat, most of them specify that uncontrolled emissions be reduced by 85 percent prior to discharge. This limit was used to estimate the baseline emissions for coil coating plants located in States that have numerical limits.

There are 36 States or parts of States that currently control VOC emissions through the use of a permit system. These States are listed in Figure 7-2. Most of the regulations for these States indicate that the degree of control required for VOC emissions is determined on a case-by-case basis at the time an application for a permit is made. For the purpose of computing baseline emissions, it was assumed that these States would require that VOC emissions be controlled to at least the level recommended by EPA in its Control Technique Guideline (CTG) document.[2]

The CTG-recommended limit is 0.31 kg/ℓ (2.6 lb/gal) of coating, minus water. The limit is expressed as a coating formulation and is equivalent to a coating that is 65 percent solids and 35 percent organic solvent. The limit was derived on the basis of the incineration of the emissions from an organic solvent-borne coating that contains 25 percent solids by volume. The emission limit can be achieved in this situation by capturing 90 percent of the emissions and directing them to a control device, which must operate with at least a 90 percent destruction efficiency. To achieve the CTG limit when the industry's average coating formulation (i.e., 60 percent organic solvent and 40 percent solids) is being used, an overall emission reduction of 64 percent would be required.

As discussed in Chapter 8, it is estimated that, over the next 5 years, the coil coating industry will expand at an annual rate of approximately 12 percent per year. With the current (1977) annual production of 1.2 billion m^2 (13 billion ft^2) per year being used as a base, this would amount to an annual increase in capacity of 0.11 billion m^2 (1.5 billion ft^2). It is further estimated that this new plant capacity will be achieved

1. Alabama[a]
2. Arizona (Maricopa County)[a]
3. California (S. Coast AQCR)[a]
4. Colorado
5. Connecticut[a]
6. District of Columbia
7. Illinois[a]
8. Indiana[a]
9. Kentucky[a]
10. Louisiana
11. Maryland (National Capital AQCR)[a]
12. Massachusetts (Boston AQCR)[a]
13. New York (NYC)[a]
14. North Carolina[a]
15. Ohio[a]
16. Oklahoma
17. Pennsylvania (Philadelphia)[a]
18. Puerto Rico
19. Rhode Island
20. Virginia[a]
21. Wisconsin[a]

[a] Denotes States in which coil coating plants are currently in operation.

Figure 7-1. List of States and major metropolitan areas currently regulating organic solvent emissions through specific numerical standards.

1. Alaska
2. Arkansas[a]
3. Arizona[a]
4. Delaware[a]
5. Florida[a]
6. Georgia[a]
7. Hawaii
8. Idaho
9. Iowa[a]
10. Kansas
11. Maine
12. Maryland[a]
13. Massachusetts[a]
14. Michigan[a]
15. Minnesota[a]
16. Mississippi
17. Missouri[a]
18. Montana
19. Nebraska
20. Nevada
21. New Hampshire
22. New Jersey[a]
23. New Mexico
24. New York[a]
25. North Dakota
26. Oregon
27. Pennsylvania[a]
28. South Carolina[a]
29. South Dakota
30. Tennessee[a]
31. Texas[a]
32. Utah
33. Vermont
34. Washington[a]
35. West Virginia[a]
36. Wyoming

[a] Denotes States in which coil coating plants are currently in operation.

Figure 7-2. List of States not regulating organic solvent emissions through specific numerical standards.

by modifying nine existing coil coating lines each year and by constructing seven new lines each year.

All emission calculations are based on the following values:

Annual (1977) production of coil coated metal	$1.2\ (10^9)\,m^2$	$(13\ (10^9)\ ft^2)$
Annual (1977) coating usage	$72\ (10^6)\,\ell$	$(19\ (10^6)$ gal)
Average organic solvent content of coatings (by volume)		
Solvent-borne		60 percent
Waterborne		10 percent
Average solids content of all coatings (by volume)		40 percent
Average solvent density	$0.88\ kg/\ell$	(7.36 lb/gal)
Fraction of plants subject to 85 percent control		0.70
Fraction of plants subject to CTG limits		0.30
Fraction of coatings that are waterborne (by total volume)		0.15

With these values, average uncontrolled (or potential) emissions from coil coating activities can be computed as $0.032\ kg/m^2$ $(0.0065\ lb/ft^2)$ when solvent-borne coatings are used and as $0.0054\ kg/m^2$ $(0.0011\ lb/ft^2)$ when waterborne coatings are used. If plant capacity increases by 0.11 billion m^2 (1.5 billion ft^2) per year, the annual increase in uncontrolled emissions would be 3,872 Mg (4,268 tons). If it is assumed that the relative usage of waterborne and solvent-borne coatings remains the same, that the geographic distribution of new plant capacity will be the same as that of existing plants, and that no add-on controls are required when waterborne coatings are used, baseline emissions from new plant capacity amount to 914 Mg (1,007 tons) per year. If no NSPS were promulgated, emissions from coil coating operations would be expected to increase by this amount annually. At the end of 5 years, the total annual increase in emissions would amount to 4,570 Mg (5,035 tons).

If an NSPS were promulgated based on the second regulatory alternative (i.e., the equivalent of an 85 percent reduction in emissions for the average industry coating formulation), emissions from new plant capacity would be 676 Mg (745 tons) per year. This is a reduction of 238 Mg (262 tons) per year from the baseline case. At the end of the fifth year, total annual emissions from new plant capacity under this regulatory alternative would amount to 3,380 Mg (3,726 tons), which is a reduction of 1,187 Mg (1,309 tons) from the baseline case. These emissions are the result of new plant capacity that becomes available each year. A portion of this new capacity is the result of modifications to existing lines. When an affected facility is modified, the existing capacity of that facility also becomes subject to the NSPS limits. The existing line capacity that annually becomes subject to these limits because of modifications is estimated to be 74 million m^2 (795 million ft^2). Baseline emissions from this volume of production are estimated to be 483 Mg (533 tons). Reductions in emissions that result from control of the existing capacity of modified lines would amount to 125 Mg (138 tons) per year under this regulatory alternative. When combined with the results of new plant capacity, the overall effect is a net increase of 551 Mg (607 tons) per year for the entire industry. This is a reduction of 363 Mg (400 tons) per year from the baseline emissions. At the end of the fifth year, the net annual increase in emissions would amount to 2,755 Mg (3,035 tons), which is a decrease of 1,815 Mg (2,000 tons) per year from the baseline emissions. The environmental impact for each regulatory alternative is summarized in Table 7-1.

If an NSPS were promulgated based on the third regulatory alternative (i.e., the equivalent of a 95 percent reduction in emissions for the average industry coating formulation), emissions from new plant capacity would be 300 Mg (331 tons) per year. This is a reduction of 613 Mg (676 tons) per year from the baseline case. At the end of the fifth year, annual emissions from new plant capacity under this regulatory alternative would total 1,500 Mg (1,655 tons), which is a reduction of 3,066 Mg (3,380 tons) from the baseline case. After control of the existing capacity of modified lines, the estimated emissions under the third regulatory alternative are 160 Mg (176 tons) per year. This is a reduction of 325 Mg (358 tons) per

TABLE 7-1. ESTIMATED ENVIRONMENTAL IMPACTS

Regulatory alternative	Emissions from new plant capacity, Mg/yr (ton/yr)		Reduction in emissions from modified plants, Mg/yr (ton/yr)		Overall impact on emissions, Mg/yr (ton/yr)	
	1st year	5th year	1st year	5th year	1st year	5th year
I. No NSPS	914 (1,007)	4,570 (5,035)	---	---	+914 (+1,007)	+4,570 (+5,035)
II. 85 percent control	676 (745)	3,380 (3,726)	-125 (-138)	-625 (-690)	+551 (+607)	+2,755 (+3,035)
III. 95 percent control	300 (331)	1,500 (1,655)	-325 (-358)	-1,625 (-1,790)	-25 (-27)	-125 (-135)

year in overall emissions. When this reduction is combined with the emissions from new plant capacity, the result is a net decrease in emissions of 25 Mg (27 tons) per year. At the end of the fifth year, the net annual decrease in emissions would amount to 125 Mg (135 tons).

There are a number of potential inaccuracies in the above discussion that are due mainly to a lack of detail in the available data. First of all, the separate calculations of emissions from solvent-borne and waterborne coatings carry an underlying implication that each type of coating is used in plants that exclusively use one or the other type of coating. It is known that this is not, in fact, the true situation. Some plants that mostly use solvent-borne coatings also use small quantities of waterborne coatings,[3] and some plants that mostly use waterborne coatings also use small quantities of solvent-borne coatings.[4] Information relating to the distribution of coating usage is not available in sufficient detail to permit more precise calculations of emissions from each type of coating.

There are also potential inaccuracies in the estimates of baseline emissions from coil coating plants. These estimates were made by assuming that existing and new plants exactly meet the standards that are in effect in the States in which they are located. It is very likely that those plants that use incineration as a method of controlling emissions are achieving a greater degree of control than state regulations require. However, it is also known that some coil coating plants now operate with no controls, either because they have been granted a variance or because the State has not required any controls. These two sources of potential inaccuracies would tend to offset one another, and it has not been possible to determine which would have the greater impact. The potential inaccuracies in the estimates of baseline emissions lead to corresponding potential inaccuracies in the estimates of the impact of an NSPS on air emissions of VOCs. However, the potential inaccuracies tend, again, to offset one another, and it is felt that the estimated impact is reasonable.

7.2 WATER POLLUTION IMPACT

Liquid effluent from coil coating operations is generated in the wet sections of coil coating lines. In the wet section, the metal is thoroughly cleaned and chemically treated to enhance the bonding of the coatings to the metal. The application of control devices on oven exhaust streams does not affect the operation of the wet section. Consequently, it is estimated that none of the regulatory alternatives would have any effect on water pollution or the liquid effluents from coil coating operations.

7.3 SOLID WASTE DISPOSAL IMPACT

The techniques available to the coil coating industry to achieve compliance with the regulatory alternatives proposed in this study include the use of incinerators and the use of low-solvent coatings. Neither of these control techniques generates additional solid wastes. It is therefore estimated that none of the regulatory alternatives would have an impact on solid waste disposal.

7.4 ENERGY IMPACT

Data on the energy consumption of existing facilities are sparse. To make estimates of the effect of regulatory alternatives on national fuel consumption, the fuel inputs to the model plants in Chapter 6 were calculated. These fuel usage rates were then converted to a basis of energy used per unit area coated and applied to the expected new production rates and modified/reconstructed production rates discussed in Section 7.1.

The fuel energy requirements of each model plant at different levels of emission control are summarized in Table 7-2. The predominant fuel for ovens and afterburners in the industry is natural gas, followed by fuel oil. Many plants burn propane when natural gas is unavailable. Electrical energy requirements of each model plant are given in Table 7-3, based on an average energy requirement of 0.26 kWh/m^2 (0.024 kWh/ft^2) coated.[5] [6]

Many coating lines located in States with CTG limits could achieve the required levels of control using only an internal, oven-mounted incineration control scheme. Because 64 percent reduction is at the upper limit of solvent destruction for these systems, each new or modified/reconstructed line must be evaluated individually. For purposes of these estimates, it is assumed that all new facilities in States with CTG limits can meet those limits with such a control system.

Plants located in States with numerical limits would have fuel and electrical needs according to the type(s) of emission control system used. With thermal incineration systems, the requirements would range from the

TABLE 7-2. RATE OF FUEL ENERGY USAGE OF MODEL COIL COATING LINES[a]

	Level of Control			
	No emission control	64 percent reduction by incineration at ovens	85 percent overall reduction by incineration at afterburner	95 percent overall reduction by incineration at afterburner with coating rooms
Model line size	kW (10^6Btu/h)	kW (10^6Btu/h)	kW (10^6Btu/h)	kW (10^6Btu/h)
Small	2,100 (7.3)	1,000 (3.4)	1,600 (5.3)	1,500 (5.0)
Medium	6,700 (23)	3,200 (11)	4,700 (16)	4,400 (15)
Large	14,000 (49)	7,000 (24)	10,000 (34)	9,400 (32)

[a] Energy rates during plant operating time.

TABLE 7-3. RATE OF ELECTRICAL ENERGY USAGE OF MODEL COATING LINES[a]

	Level of Control			
	No emission control	64 percent reduction by incineration at ovens	85 percent overall reduction by incineration at afterburner	95 percent overall reduction by incineration at afterburner with coating rooms
Model line size	kW	kW	kW	kW
Small	190	190	300	300
Medium	680	680	900	900
Large	1,300	1,300	1,800	1,800

[a] Energy rates during plant operating time.

higher fuel needs and lower electrical needs of a system with an afterburner only to the lower fuel needs and higher electrical needs of a system with an afterburner and primary and secondary heat exchangers. In this chapter, the estimates of energy usage for control systems meeting numerical limits and NSPS limits are based on the use of thermal incineration with primary and secondary heat recovery. This basis reflects the trend in the industry toward energy savings by heat recovery. Although the economics of the systems generally favor the use of heat recovery, the actual type of system installed on a line will depend on corporate policy, the availability of fuel, and other factors.

The effects of the regulatory options on national fuel consumption are estimated in Table 7-4, based on the projected construction of seven new lines per year and the projected modification or reconstruction of nine existing lines per year, as discussed in Section 7.1. The assumption is made that the distribution of new and modified or reconstructed lines by location will be the same as that of existing lines. The increase in national fuel demands is highly dependent on the types of control systems installed. The values given in these tables are order-of-magnitude estimates and are subject to inaccuracy for the same reasons discussed in Section 7.1.

The national increase in electrical energy demand due to growth in the industry is extremely difficult to predict. There are little data on existing lines because many coil coating lines are located in facilities that use electricity for other operations and because the focus in the literature has been on fuel conservation. However, an order-of-magnitude estimate can be made using figures of 0.26 kWh/m^2 (0.024 kWh/ft^2) of production (lines meeting NSPS or numerical limits) and 0.18 kWh/m^2 (0.017 kWh/ft^2) of production (lines meeting CTG limits). The annual increase in national electrical energy usage under Regulatory Alternative I, No NSPS, is estimated at 40 million kWh. The annual increase under either NSPS alternative is estimated at 44 million kWh.

Several methods are available to reclaim heat energy and thus reduce overall energy consumption, including the use of recuperative heat exchangers as in the model plants. Various systems are described in detail in Chapter 4. These include recuperative and regenerative heat recovery, in

TABLE 7-4. ESTIMATED ANNUAL INCREASE IN NATIONAL FUEL CONSUMPTION DUE TO INDUSTRY GROWTH[a]

Regulatory alternative	Increase in fuel consumption First year TJ[b] (billion Btu)	 Fifth year TJ (billion Btu)
I. No NSPS	700 (660)	3,500 (3,300)
II. Limiting emissions to the equivalent of that obtained by an overall reduction of 85 percent in the emissions from the average industry coating formulation of 40 percent solids and 60 percent solvent by volume	770 (730)	3,850 (3,650)
III. Limiting emissions to the equivalent of that obtained by an overall reduction of 95 percent in the emissions from the average industry coating formulation of 40 percent solids and 60 percent solvent by volume	740 (700)	3,700 (3,500)

[a] Assumptions:

1. Wherever 85 or 95 percent reduction is required, new and modified/reconstructed lines using solvent-borne coatings install thermal incineration systems. These systems include primary and secondary heat recovery or equivalent heat recovery.
2. Systems with 95 percent control include coating rooms.
3. CTG levels of control are achieved by coating rooms and ovens using solvent combustion.
4. Incineration temperature for 85 and 95 percent control is 760° C (1,400° F).
5. Lines using waterborne coatings meet NSPS limits by choice of coating formulation rather than by installation of emission control equipment.

[b] TJ = terajoule, 10^{12} joules.

which incinerator exhaust gases are used to preheat oven make-up air and/or incinerator inlet air. Process steam is also produced in some plants from the heat of exhaust gases. Other systems use direct recycle to return afterburner exhaust gases directly to the ovens; since the exhaust streams have been cleaned of solvent, safe solvent levels are maintained in the ovens with a minimum ambient make-up air requirement.

7.5 OTHER ENVIRONMENTAL CONCERNS

7.5.1 Irreversible and Irretrievable Commitment of Resources

Each of the control alternatives considered requires the commitment of a quantity of steel and various other materials to construct emission control systems. This commitment is estimated to be quite small relative to the total annual usage of these materials. Some of the emission control systems require a small commitment of land area for installation. Although there may be individual coaters with limited available space for whom this land requirement is a problem, it is estimated to be a minor consideration on a national basis. The energy impact of the control alternatives is described in the preceding section and shows that there is a net increase in energy consumption for each of the NSPS regulatory alternatives but that the impact is minimized when incineration with heat recovery is used.

7.5.2 Environmental Impact of Delayed Standards

If promulgation of an NSPS is delayed for some period of time, VOC emissions from coil coating operations would increase at an annual rate equal to the No NSPS alternative discussed above in Section 7.1. Relative to the second regulatory alternative (i.e., requiring plants to reduce emissions by 85 percent), the net annual increase in emissions during the delay would be 603 Mg (664 tons). Relative to the third regulatory alternative (i.e. requiring all plants to decrease emissions by 95 percent) the net annual increase in emissions during the delay would amount to 1,059 Mg (1,167 tons).

7.6 REFERENCES

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8. ECONOMIC IMPACT

8.1 INDUSTRY CHARACTERIZATION

Coil coating is a process by which metal is coated prior to its formation into end products. The process originated in the 1930s as a method of coating metal to be used in making venetian blinds, but, because of the efficiency and cost-effectiveness of the process, its use has expanded to many other products. The process begins with a roll (or coil) of bare sheet metal and ends with a roll of metal that has one or two coats of finish on one or both sides. Coatings are applied with rollers, which are virtually 100 percent efficient in transferring the coating to the metal surface. The process is also more energy efficient than most postassembly coating operations because of the continuous nature of the process. It has been estimated that coil coating uses only about one-fifth of the energy that would be required by a postassembly coating operation.[1] This section presents a description of the coil coating industry and identifies the companies and plants that are engaged in the process.

8.1.1 General Profile

A total of 83 companies have been identified that engage in the production of coil coated metal. These companies own approximately 109 plants containing an estimated 147 coil coating lines that produce precoated steel and aluminum for domestic consumption. Coil coating facilities are typically located in or near industrial areas to minimize the shipping costs of both raw materials and the final product. Although plants are dispersed throughout 27 States, over one-half of the existing facilities are located in Illinois, Ohio, Pennsylvania, and California. However, facilities are not heavily concentrated in any one locality within these States. On an EPA Regional basis, Region V represents about 34 percent of existing coil coating plants, and Region IV, about 12 percent. A listing of all identified companies and plants is contained in Table 8-1, along with the number of lines per plant, plant location, and company ownership, where applicable.

The majority of coil coating establishments are privately owned or operated. Analysis of available data indicates that, of the 83 companies identified, a total of 42 are subsidiaries of conglomerates or of major iron, steel, or aluminum manufacturing concerns. Existing plants are, on the average, about 23 years old and have had a renovation or upgrading of a coil coating line within the last 6 years.[2]

"Toll" and "captive" coaters represent the two basic structural divisions of this highly competitive industry. The toll coater is a service coater that accepts an order to coat steel or aluminum according to a customer's needs and specifications. The coated metal is then delivered to the customer, who forms the end product. Some large toll coaters use up to 1,000 different formulations of coatings. In contrast, the captive coater both coats the metal and fabricates the final product, often within the same plant, and normally uses a smaller number of coating formulations. Some coil coaters perform both toll and captive coating services.

Coated metal coil is not generally considered an end product because it is usually cut and formed into other metal products by the purchaser. Coated metal coil has historically been associated with building products such as venetian blinds, curtain and drapery hardware, and exterior wall and roof panels but has recently been formed into many new end products. During 1977, the transportation industry was the largest single user of coil coated metal, and the large appliance industry is expected to be an expanding market in coming years. A list of current and suggested end uses of coil coated metal, supplied by the National Coil Coaters Association (NCCA), is contained in Table 8-2.

Estimated North American shipments of coated metal coil reached over 3.4 million Mg (3.7 million tons) in 1977, a 19 percent increase over 1976 shipments. Coated steel coil accounted for over three-fourths of 1977 production, with estimated shipments of 2.6 million Mg (2.9 million tons). Much of the 22 percent increase over 1976 shipments is accredited to the larger shipments of coated steel purchased by the transportation industry. Precoated aluminum shipments reached an estimated 709,415 Mg (782,000 tons) in 1977, an increase of 8.6 percent over the previous year. The nearly 3.6

TABLE 8-1. DOMESTIC COIL COATING ESTABLISHMENTS CURRENTLY IN OPERATION: 1979[2] [3]

Company/Subsidiary[a]	Plant location(s)	Estimated number of lines per plant
Alan Wood	Pennsylvania	1
Alcan Aluminum Ltd. (Canada)	Ohio	1
Alcan Aluminum Corp.	Pennsylvania	1
	California	1
Almax Aluminum Mills	California	1
Alsar Manufacturing	Michigan	1
	Pennsylvania	1
Aluminum Company of America	Iowa	1
	Indiana	1
	Tennessee	1
Stolle Corp.	Ohio	1
AMAX Inc. (50%) Mitsui and Co. (45%) Nippon Steel Co. (5%)		
Alumax Mill Products	California	2
	Illinois	1
American Nickeloid	Illinois	1
	Pennsylvania	1
Amsted Industries Incorporated		
Litho Strip Co.	Illinois	1
	Illinois	2
	Texas	1
	Pennsylvania	1
Anta Corporation		
Nichols-Homeshield Inc.	Iowa	1
	Illinois	1
Apollo Metals, Inc.	New Jersey	1
	Pennsylvania	1
Armco Steel	Ohio	1
Arvin Industries, Inc.		
Roll Coater, Inc.	Indiana	2
	Indiana	1

[a] Subsidiaries are indented.

(continued)

TABLE 8-1. (continued)

Company/Subsidiary[a]	Plant location(s)	Estimated number of lines per plant
Atlantic Richfield		
Anaconda	Ohio	1
	Ohio	2
Banyon Corporation		
Hydrographics Corporation	Texas	1
Belmont Industries, Inc.		
Supra Cote, Inc.	California	1
Bendix Corporation		
Modern Materials Corporation	Michigan	3
Chamberlain Manufacturing Corp.	Pennsylvania	1
Chicago Metallic Corp.		
California Finished Metals, Inc.	California	1
Chesapeake Finished Metals, Inc.	Maryland	1
Chicago Finishing	Illinois	1
Chromalloy American		
Precoat Metals	Missouri	2
Arrow Group	New Jersey	1
Clark Brothers	Michigan	1
Consolidated Foods		
Graber Co.	Wisconsin	2
Consolidated Systems		
Southeastern Coated Products	South Carolina	1
Cortland Container Corporation	Texas	1
Custom Metals	Illinois	1
Cyclops Corp.		
E.G. Smith	Pennsylvania	1
	Ohio	1
Donn Corporation		
American Metals	Ohio	1
Edco Products, Inc.	Minnesota	1

[a] Subsidiaries are indented.

(continued)

TABLE 8-1. (continued)

Company/Subsidiary[a]	Plant location(s)	Estimated number of lines per plant
Enameled Steel and Sign Company	Illinois	1
Epic Metals Corp.	Ohio	1
	Pennsylvania	1
Finished Metals Inc.	Illinois	1
Fruehauf	Alabama	1
Globe Products Corp.	Maryland	1
Groff Industries, Inc.	Texas	1
Hexcel Corporation	Arizona	1
	Texas	1
Hillman Coal and Coke Co., Inc.		
Prior Coated Metals, Inc.	Pennsylvania	2
	Pennsylvania	1
	Georgia	1
Hoechst A. G. (Germany)		
Azoplate	New Jersey	3
Hunter-Douglas N. V.		
Hunter-Douglas	North Carolina	1
Imperial Metals	California	1
Inland Steel		
INRYCO	Wisconsin	1
Kaiser Aluminum	Washington	3
	Ohio	3
Kirsch Company	Michigan	1
Landsdale Finishing	Pennsylvania	1
Lawler Steel Components, Inc.	Texas	1
Levolor-Lorentzen, Inc.	West Virginia	2
	California	1
	New Jersey	5
Lifeguard Industries, Inc.	Ohio	1
LTV Corp.		
Jones and Laughlin Steel Corp.	Texas	1
Marathon Manufacturing		
Marathon-Carey-McFall	Pennsylvania	1

[a] Subsidiaries are indented.

(continued)

TABLE 8-1. (continued)

Company/Subsidiary[a]	Plant location(s)	Estimated number of lines per plant
Martin Marietta	Kentucky	1
Marwais Steel	California	1
Minnesota Mining & Manufacturing	West Virginia	1
Mirro Aluminum	Washington	1
Material Sciences Corporation		
Prefinish Metals Inc.	Illinois	1
	Illinois	2
National Steel Corporation		
Enamel Products & Plating	Pennsylvania	2
	Indiana	1
National Aluminum	Kentucky	1
Hastings Aluminum	Michigan	2
National Rollex	Wisconsin	1
N. E. Co. Limited Int.		
Aluminum Mills, Inc.	California	1
Noranda Mines Ltd. (Canada)		
Norandex	Ohio	1
Omega Industries	Texas	1
Phelps Dodge Corp.		
Consolidated Aluminum	Tennessee	1
	Missouri	1
Pechiney Ugine Kuhlmann (France)		
Howmet Corp.	Pennsylvania	2
	Texas	1
Republic Steel Corp.	Ohio	1
Revere Copper and Brass, Inc.		
Revere Aluminum Building Products	Illinois	1
	Alabama	1
Reynolds Metals Company	Alabama	1
Alloys Sheet & Plate	Alabama	2
McCook Sheet & Plate	Illinois	1
Asheville Arch	Ohio	1

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[a] Subsidiaries are indented.

(continued)

TABLE 8-1. (continued)

Company/Subsidiary[a]	Plant location(s)	Estimated number of lines per plant
Rosewall Industries, Inc.		
Plasteel Products Corporation	Pennsylvania	1
Sears Roebuck		
Roper Eastern	Maryland	5
Stanley Works	Connecticut	6
Teledyne, Inc.		
Teledyne-Rodney	Massachusetts	2
Thomas Steel Strip Corporation	Ohio	1
U.S. Steel Corporation	Alabama	1
Alside, Inc.	Ohio	2
Wheeling-Pittsburgh Steel Corporation		
Pittsburgh-Canfield	Ohio	1
Wheeling Corrigated	West Virginia	1
Wolverine Aluminum Corporation	Michigan	3
Zeeger, Inc.	Illinois	1

[a] Subsidiaries are indented.

TABLE 8-2. CURRENT AND SUGGESTED END USES OF PRECOATED METAL STRIP[4]

Appliances--Large

1. Air conditioners
2. Clothes dryers
3. Dish washers
4. Furnaces
5. Gas or electric ranges
6. Radio and phonograph cabinets
7. Refrigerator and freezer liners
8. Refrigerator and freezer--doors and shells
9. Space Heaters
10. Vending machines
11. Washing machines
12. Water coolers
13. Water heater jackets

Appliances--Small

1. Beauty shop equipment coin-op equipment
2. Business machine housings
3. Can openers
4. Clock faces and housings
5. Coin-op equipment
6. Dehumidifiers
7. Electric fan blades
8. Floor waxers
9. Hair dryers
10. Homogenizers
11. Household cooking appliances
12. Humidifiers
13. Knife sharpeners
14. Miscellaneous parts for appliances (braces, brackets, etc.)
15. Radio & TV cabinets
16. Sewing machines
17. Sound recording equipment
18. Vacuum cleaners
19. Watches and clocks

Construction

1. Accessories for siding, facia, trim, corners, etc.
2. Awnings and canopies
3. Baseboard heating covers
4. Bathroom cabinets
5. Building soffit systems
6. Bus stop shelters
7. Carports, boat shelters
8. Car wash booths
9. Ceiling tile
10. Commercial building marquees
11. Construction machinery
12. Curtain wall and building sheet (Supermarkets, aircraft hangers, factories, schools, etc.)
13. Decorative chimnies
14. Decorative shutters
15. Doors
16. Door and window frames
17. Ductwork
18. Electrical switch and outlet plates
19. Elevator and escalator paneling
20. Fabricated sections for bridges and buildings
21. Fencing
22. Fireplaces

(continued)

TABLE 8-2. (continued)

23. Garage doors
24. Gutters and downspouts
25. Interior partitions and trim
26. Kitchen cabinets
27. Lighting reflectors and housings
28. Louvered vents
29. Partitions and fixtures
30. Patio covers and supports
31. Radiator fin stock
32. Refreshment booths (to house vending machines)
33. Residential siding
34. Roof decking
35. Roof flashing
36. Roof shingles and sheet
37. Sanitary ware (metal)
38. Screen frames
39. Shower stalls
40. Signs and advertising displays
41. Silo roofs
42. Stadium seats
43. Staircases, railings, scaffolds
44. Storage sheds, tool sheds
45. "T" Bar hangers for tile
46. Telephone booth--paneling
47. Walkway covers and supports
48. Wall tile

Machinery, Farm and Garden Equipment

1. Animal shelters
2. Farm storage bins
3. Feed troughs
4. Garden Equipment
5. Grain dryers
6. Large farm machinery
7. Blowers and fans
8. Food products machinery
9. Industrial controls
10. Machine tool accessories
11. Paper industry machinery
12. Printing industry machinery
13. Stampers, roll formers
14. Switchgear
15. Textile machinery
16. Mowers
17. Snowblowers
18. Spreaders
19. Tools

Furniture
(Residential and Commercial)

1. Cabinets (storage, beverage, functional)
2. Card tables
3. Chairs
4. Clothes hampers
5. Coat racks
6. Desks
7. Display cases
8. Filing cabinets
9. Fireplace accessories
10. Institutional furniture
11. Ironing boards
12. Juvenile furniture
13. Ladders and ironing boards

(continued)

TABLE 8-2. (continued)

14. Lamps and shades
15. Lawn furniture
16. Library shelving
17. Lockers
18. Metal drawers dividers
19. Radiator covers
20. Shelving
21. Store fixtures
22. Switchboards
23. Tubular products, legs, stands, etc.
24. T.V. trays
25. Waste baskets

Packaging

1. Bulk containers
2. Cans and containers
3. Caps and closures
4. Drums, barrels, pails
5. Edging for cartons
6. Film canisters
7. Semi-rigid container (T.V. dinner trays, etc.)

Recreational Equipment

1. Aluminum boats
2. Bar-B-Q Grills
3. Basketball backboards
4. Camping equipment (ice boxes, camp stoves, etc.)
5. Exercising equipment
6. Fabricated play houses
7. Folding camp cots and chairs
8. Golf carts
9. Picnic jugs
10. Playground equipment
11. Portable swimming pool frames and sheathing
12. Prefabricated baseball dugouts

Transportation

1. Aircraft, bus, and train ceilings
2. Aircraft, parts, equipment and trim
3. Arm rests
4. Automotive trim
5. Baggage racks
6. Bicycle fenders
7. Car bodies
8. Commercial truck sheathing
9. Conveyors
10. Highway guard rails
11. Instrument panels
12. Interior door panels and trim
13. License plates
14. Locomotive and parts
15. Miscellaneous parts, horn shells, voltage regulators, oil caps, braces, oil filters, canisters, clutch plates for automatic transmissions, etc.
16. Mobile home sheating and interior components
17. Railroad and street cars
18. Recreational vehicle
19. Shipbuilding and repairing
20. Snowmobiles
21. Station wagon flooring
22. Trailer sheathing
23. Truck and bus bodies
24. Window frames

(continued)

TABLE 8-2. (continued)

Miscellaneous

1. Athletic and sporting goods
2. Blackboards (metal)
3. Bread boxes
4. Camera shells and parts
5. Casket handles
6. Communications equipment
7. Dental equipment
8. Dispensing machines, towels, etc.
9. Drapery fixtures and curtain rods
10. Electrical measuring equipment
11. Games, toys
12. House numbers
13. Instrument gauge faces, clocks, thermometers, etc.
14. Instrument panels
15. Luggage
16. Mail boxes
17. Metal signs (interior and exterior)
18. Morticians goods
19. Musical instruments
20. Ordnance and accessories
21. Photographic equipment
22. Picture frames
23. Pins and mechanical pencils
24. Tool and tackle boxes
25. Utensils
26. Window blinds, venetian blinds, pivot shades, and accessories

million Mg (4 million tons) of coil coated metal currently produced per year represents an estimated product value of over $3.5 billion.[1]

Industry sources indicate that the industry currently operates at about 65 percent of its maximum practical capacity,[1] compared to 67 percent for the metal coating industry as a whole.[5] Practical capacity is defined as the greatest level of output the plant can achieve within a realistic work pattern.[5] If all lines run at full capacity, implied production is estimated at more than 1.86 billion m^2 (20 billion ft^2) of coated metal annually. Total actual production in 1977 reached 1.21 billion m^2 (13 billion ft^2) and had an average product value of $2.47/$m^2$ (23¢/ft^2).[1]

Analysis of available information indicates that the industry is not dominated by any one company but that several companies are among the production leaders. Approximately one-half of the coil coaters coat both aluminum and steel in nearly equal amounts by area coated, while the other half specialize in the production of either aluminum or steel. The industry as a whole is fairly well balanced between the production of the two types of metal by area coated.

Continuous, high-volume production is a significant operating characteristic of the industry and is necessary to achieve and maintain competetive pricing in the industry. Plants generally run an average of two to three shifts per day, 5 to 7 days a week. Based on discussions with a number of industry sources, it is estimated that coatings are applied during approximately 75 percent of each employee shift. The remaining time is expended performing maintenance and color changes. Coil coating lines are highly automated and require only minimal production line employment. Although a few large plants employ 100 to 200 persons, analysis of existing data indicates that average employment at coil coating plants is about 38 persons and that about 10 percent of the existing facilities employ fewer than 10 persons.[3]

Although numerous factors affect the pricing of coating services, the most important factors include the cost of the coating; the gauge, width, and weight of the metal to be coated; and the size of the order. Coil coating plants tend to have a stable core group of customers, and economy of scale is achieved through mass production. Significant variations in unit price per order prevail throughout the industry, and there is no comprehensive printed price list. However, a list of average prices of coating per square foot of coated metal was constructed during an industry analysis conducted by the EPA Effluent Guidelines Division.[6] This list is given in Table 8-3 and shows that the average price ranges between 16.1¢/m^2 and \$2.15/m^2 (1.5¢/ft^2 and 20¢/ft^2) of metal coated. Although the prices of 11 of the 25 coatings listed in Table 8-3 are above \$1.08/m^2 (10¢/ft^2), the prices of the most widely used coatings fall below this range. It is estimated that the weighted average price for all coating services performed by a typical coater is approximately 43¢/m^2 (4¢/ft^2) of metal coated.[7] Industry sources have reviewed these figures and found them to be representative of the industry.

The current major markets for coil coated steel and aluminum include the transportation industry, the building products industry, the containers and packaging industry, and the large appliance industry. Despite the continued growth of the building products market during 1977, the transportation industry has emerged as the single largest user of coil coated steel, and large appliances is seen as an expanding future market for coil coated steel. The building products industry and the containers and packaging industry remain the two major markets for coated aluminum coil.[8] Tables 8-4 and 8-5 indicate 1976 and 1977 shipments of coil coated steel and aluminum to those markets and includes shipments for other major end uses of each type of metal.

Because of the cost efficiency of coil coated metal, few acceptable substitutes for precoated steel and aluminum are available. The growing desire of manufacturers to avoid the pollution problems associated with postassembly painting creates an additional incentive for the use of precoated metal. Industry sources indicate that sheet coating is the only process that is in direct competition with coil coating in the precoated metals market. The major market for sheet coated metal is the metal can industry for the manufacture of three-piece cans and can ends. Sheet coating is not considered by industry sources to affect significantly other coil coating markets.[9] [10]

According to industry sources, most coil coated metal is manufactured for domestic consumption, and exports are considered to have little or no impact on the American market.[9] No specific information regarding the

TABLE 8-3. COATINGS, PRICES, AND METALS COATED[7]

Coating	Price/m^2 (ft^2)	Metal coated
Weldable primer	$0.16 (1.5¢)	S
Zincrometal	$0.19 (1.8¢)	S
Epoxy	$0.86 (8.0¢)	A,S,G
Epoxy-ester	$0.38 (3.5¢)	A,S,G
Acrylic	$0.38 (3.5¢)	A,S,G
Siliconized acrylic	$1.61 (15.0¢)	A,G
Alkyd	$1.16 (1.5¢)	A,S,G
Fluorocarbon (pvf and pvf_2)	$2.15 (20.0¢)	A,G
Fluorocarbon (ptfe)	$2.15 (20.0¢)	A,S,G
Phenolic	$0.27 (2.5¢)	A,S,G
Polyester (oil free)	$0.43 (4.0¢)	A,S,G
Silicone polyester	$0.86 (8.0¢)	A,G
Solution vinyl	$0.86 (8.0¢)	A,S,G
Urethane	$1.94 (18.0¢)	A,S,G
Organosol	$0.38 (3.5¢)	A,S,G
Plastisol	$0.22 (2.0¢)	A,S,G
Acrylic film	$1.61 (15.0¢)	A,S,G
Polyvinylchloride film	$1.61 (15.0¢)	A,S,G
Polyvinylfluoride	$2.15 (20.0¢)	A,S,G
Polyester film	$1.08 (10.0¢)	A,S,G
Polyolefin film	$0.27 (2.5¢)	A,S,G
Prints of two or more colors	$1.83 (17.0¢)	A,S,G
Plastisols and organosols	$1.94 (18.0¢)	A,S,G
Polyphenylene sulfide	$2.15 (20.0¢)	A,G
Water and alkali soluble	$0.16 (1.5¢)	A,S

A = Aluminum.
S = Cold-rolled steel.
G = Galvanized steel.

TABLE 8-4. SHIPMENTS OF PRECOATED ALUMINUM AND STEEL: 1976 and 1977

	Aluminum		Steel	
	1976	1977	1976	1977
Industry users	Megagrams (tons)	Megagrams (tons)	Megagrams (tons)	Megagrams (tons)
Building products	316,419 (348,794)	308,753 (340,344)	715,320 (788,509)	795,054 (876,402)
Transportation	29,707 (32,747)	60,747 (66,962)	646,680 (712,846)	837,712 (923,424)
Appliances	5,054 (5,571)	17,040 (18,783)	65,595 (72,306)	84,246 (92,866)
Containers & packaging	144,059 (158,799)	163,271 (179,976)	66,313 (73,098)	58,403 (64,379)
Furniture, fixtures, & equipment	1,057 (1,165)	3,126 (3,446)	78,764 (86,823)	69,395 (76,495)
Other users	24,931 (26,931)	107,159 (118,123)	103,598 (114,198)	97,054 (106,985)

TABLE 8-5. MAJOR MARKETS FOR PRECOATED METAL: 1976 AND 1977[a]

Markets	Megagrams (tons) of metal shipped	
	1976	1977
Aluminum markets		
Residential siding	144,127 (158,874)	157,776 (173,919)
Cans, ends & tabs	132,608 (146,176)	151,568 (167,076)
Service centers & distributors	14,118 (15,563)	61,718 (68,033)
Mobile homes	61,999 (68,343)	53,380 (61,046)
Travel trailers & campers	19,196 (21,160)	26,086 (28,755)
Trucks, trailers & shipping containers	7,315 (8,063)	24,171 (26,644)
Awnings & canopies	17,352 (19,127)	21,303 (23,483)
Rain carrying equipment	21,787 (24,016)	21,033 (23,185)
Steel markets		
Passenger automobiles	494,804 (545,431)	780,570 (860,436)
Industrial, rural buildings	422,193 (465,390)	546,216 (602,103)
Lighting fixtures	37,006 (40,792)	55,210 (60,859)
Trucks, trailers & shipping containers	18,333 (20,209)	52,424 (57,788)
Shelving & fixtures	40,764 (44,935)	39,609 (43,662)
Heating, water heating & water softening equipment	17,157 (18,912)	36,773 (40,536)
Container strapping & seals	32,939 (36,309)	35,894 (39,567)
Portable buildings & parts	32,231 (35,529)	34,400 (37,920)

import or export of coil coated metal was identified from government or industry sources because data on precoated metal are included in overall figures for production, imports, and exports of steel and aluminum.

The standard government publications that contain industry statistics on shipments, employment, and production did not yield any information that is specifically related to the coil coating industry. The reason for this lack of data is that coil coating is identified by a seven-digit Standard Industrial Classification (SIC) code, and none of the statistics is reported to that level of detail. Most of the data are reported at the four-digit level. Coil coating as an independent process is included in SIC code 3479, Metal Coating and Allied Services, which also includes numerous other metal coating processes. The captive coil coaters may be included in the SIC code for their parent companies, which may be producers of aluminum or steel, or may be classified by their major product. Because of this lack of published data, most of the information contained in the above discussion was provided by sources within the coil coating industry.

8.1.2 Trends

8.1.2.1 Historical Trends. Since its inception in the 1930s, the coil coating industry has demonstrated a steady rate of growth. During the 10-year period from 1968 through 1977, the industry grew, on the average, about 14 percent each year.[8] This may be compared to an annual growth rate of 8.8 percent for the metal coating industry as a whole during the same period.[11] Although shipments of both precoated steel and aluminum declined sharply during the 1974-1975 recession, production quickly recovered by 1976. Total shipments of precoated metal from 1968 through 1977 are indicated in Table 8-6 along with the percent change per year in the production of steel and aluminum.

Shipments of precoated aluminum coil increased an average of 9.6 percent each year from 1968 through 1977, and shipments of precoated steel grew by nearly 16 percent each year during the same period. The rapid growth of precoated steel has corresponded to an increase in demand in both new and existing markets, such as the transportation and large appliance industries, respectively. Because both aluminum and steel production have shown significant growth in recent years, it does not appear that one segment is growing at the expense of the other. Imports and substitute

TABLE 8-6. ESTIMATE OF TOTAL SHIPMENTS OF PREPAINTED OR PRECOATED METAL COIL BY COATERS LOCATED IN THE UNITED STATES, CANADA, AND MEXICO[8]

[thousands of megagrams (tons)]

Year	Aluminum	Percent change	Steel	Percent change	Total	Percent change
1968	411 (453)	+ 24.6%	919 (1,013)	+ 17.7%	1,330 (1,466)	+ 19.7%
1969	526 (580)	+ 27.9%	1,072 (1,182)	+ 16.8%	1,598 (1,762)	+ 20.2%
1970	499 (550)	- 0.4%	1,031 (1,137)	+ 0.4%	1,530 (1,687)	- 0.4%
1971	600 (661)	+ 20.1%	1,146 (1,263)	+ 11.1%	1,746 (1,924)	+ 14.0%
1972	662 (730)	+ 10.3%	1,305 (1,439)	+ 13.8%	1,967 (2,169)	+ 12.7%
1973	752 (829)	+ 13.6%	1,690 (1,863)	+ 29.4%	2,442 (2,692)	+ 24.1%
1974	641 (707)	- 14.7%	1,893 (2,087)	+ 12.0%	2,534 (2,794)	+ 3.8%
1975	526 (580)	- 18.0%	1,301 (1,434)	- 31.3%	1,827 (2,014)	- 27.9%
1976	653 (720)	+ 24.1%	2,184 (2,407)	+ 67.9%	2,837 (3,127)	+ 54.9%
1977	709 (782)	+ 8.6%	2,671 (2,944)	+ 22.3%	3,380 (3,376)	+ 19.2%
Average growth per year	+ 9.6%		+ 15.9%		+ 14.0%	

products have had little or no effect on growth trends during the past 10 years.[9]

During the past 10 years, expansion of industry capacity has been achieved through the construction of new coil coating lines and through modifications of existing facilities. Based on data obtained from the EPA Effluent Guidelines Division,[2] it is estimated that a total of 18 new lines have been constructed since 1970 and that 55 lines have undergone modification since that time. The ratio of modifications to new lines has been about 3 to 1 during the past decade. Although some of the newer lines have dramatically higher production rates than most existing lines, smaller lines also continue to be built. New plant construction has not substantially modified the geographic distribution of the industry in recent years.

8.1.2.2 Future Trends. The coil coating industry is highly capital intensive and fast growing. Led by the increased use of precoated metal in the transportation and appliances industry, the demand for coil coated steel and aluminum is expected to grow significantly in the future. Contrary to the lower annual growth rate of 4 to 5 percent forecast for most industries that purchase precoated metal, it is estimated that the coil coating industry will grow at an average annual rate of 12 percent through 1985.[12 13] Projections of total shipments of precoated metal for the 5-year period from 1981 through 1985 are indicated in Figure 8-1. By 1985, total shipments of coil coated metal are expected to reach approximately 6.9 million Mg (7.6 million tons), as compared to approximately 3.4 million Mg (3.7 million tons) during 1977. Projections are based on an annual growth rate of 12 percent of the base year (1977) production through 1985. This amounts to an annual increase of approximately 0.45 million Mg (0.50 million tons) per year during this period.

Although existing facilities will absorb a portion of this anticipated growth during the next few years, new and modified lines will be necessary to maintain the growth rate. At least three major manufacturers are known to be planning the construction of new lines to be in operation by the early 1980s. As discussed in Chapter 5, the most prevalent modification to coil coating lines will be for the purpose of increasing line speed.

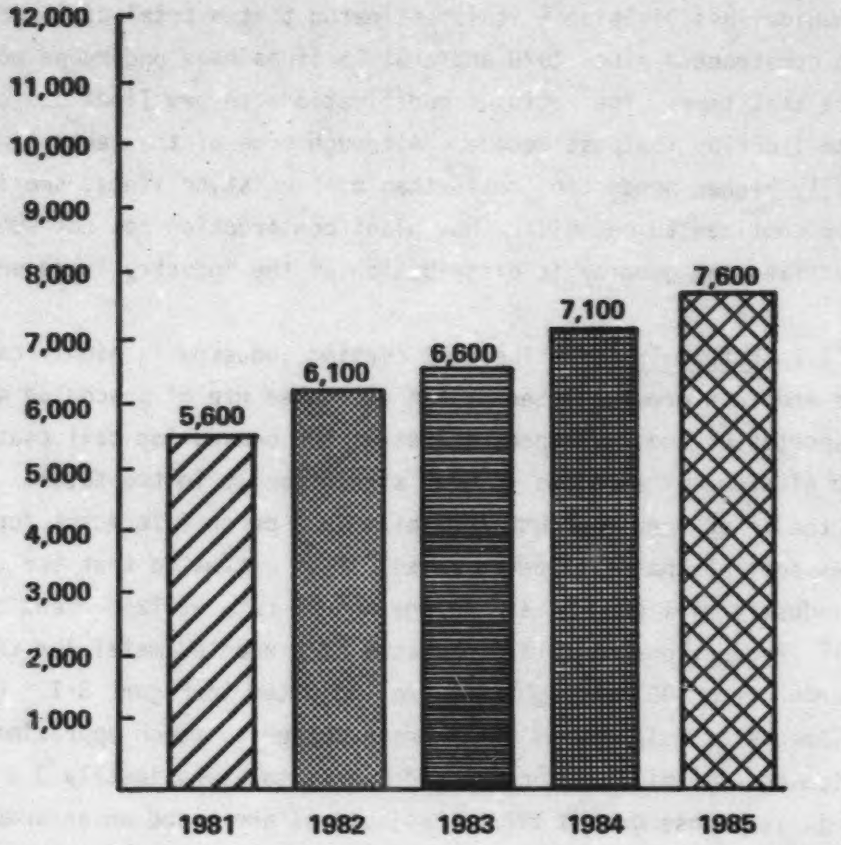

Figure 8-1. Total projected shipments of precoated metal: 1981-1985. (in thousands of tons)

The projected growth in the production of coil coated metal is equivalent to an annual increase in production of 139 million m^2 (1.5 billion ft^2). This projected growth is equivalent to three large, two medium, and two small new model plants per year and the modification of nine existing plants per year. As mentioned previously, some of the newer lines have a much higher production capacity than previous ones. For example, Roll Coater, Inc., and Prefinish Metals each have lines operating or under construction that are capable of processing metal up to 1.83 m (72 in.) wide at speeds in the range of 3.5 to 4.0 m/s (700 to 800 ft/min). One line of this capacity is equal to several lines in the size ranges of the model plants. The estimate of the number of new lines is made only to represent the expected increase in production capacity. The actual number of lines built may be more or less than the estimates depending on the capacity of each new line. Major replacement of equipment for existing lines is not typical of the coil coating industry. Routine replacement of line components, such as the wet section, which may occur every 2 to 5 years, does not constitute a modification because it does not impact production or emissions.

Areas of growth will include the deeper penetration of existing markets in addition to the entrance into new markets not yet explored by the industry. Increased sales to the transportation industry for such products as trucks, trailers, and recreational vehicles are expected. Industry spokespersons also believe the large appliance industry to be on the verge of a major switch to precoated stock.[5] Advances in coating formulations, energy conservation measures, and the desire to avoid postassembly painting and its resultant pollution control problems are expected to be additional factors that will lead to increased sales of precoated metal coil. Competition with imports or substitute products is not expected to dampen industry growth.

The actual coating process, the size of lines, and the geographical concentration of new lines are not expected to change to any significant degree over the next 5 years. However, improved operating characteristics on new and existing lines, such as increased line speed and the addition of dual coating heads, which allow color changes to be made without interrupting the coating process, will contribute to industry growth. New lines will incorporate an even higher degree of automation, resulting in lower labor cost and greater economy of scale in production. Examples of recent innovations include automatic film (coating) thickness monitoring and strip temperature measurement using infrared techniques. In addition, advances in coating formulations will enable new industries to use precoated steel or aluminum in their manufacturing processes. For coil coated metal to be used in a product, the coatings not only must be capable of withstanding the normal conditions of the products' use, but must also withstand manufacturing operations such as cutting, bending, and joining. Two recent innovations that have led to new markets for coil coated steel are (1) a polyester coating that is induction heated during roll forming operations to radii as small as twice the metal thickness and (2) a weldable primer.[14] The first of these developments is used by General Electric to manufacture refrigerator doors and wrappers, and the latter is used by the automobile industry.

8.2 COST ANALYSIS OF CONTROL OPTIONS

8.2.1 Introduction

In this section the costs of various control options are presented and analyzed. The control options, discussed in Chapter 4, are summarized in Table 8-7, along with the regulatory alternatives to which each applies. (See Appendix E for a description of a set of revised control options and regulatory alternatives.) The model coil coating lines presented in Chapter 6 form the basis for all cost analyses in this section. Figure 8-2 lists key parameters for each model line size. The metal sizes and production rates of the model lines are based on responses to an industry survey of all known facilities.

The first regulatory alternative, No New Source Performance Standard (NSPS), corresponds to the level of control expected under the State Implementation Plans (SIPs). The SIP limits applicable to particular coating lines vary geographically, depending on whether Control Technique Guideline (CTG) limits or numerical limits apply. As described in Chapter 7, the average level of volatile organic compound (VOC) control required in those areas that use CTG limits is 64 percent overall, while the average level of control required in States that use numerical limits is 85 percent overall (approximately equivalent to 90 percent capture and 95 percent destruction

TABLE 8-7. REGULATORY ALTERNATIVES AND CONTROL OPTIONS CONSIDERED IN THE ECONOMIC ANALYSIS

	Regulatory alternative	Control option
I.	No NSPS (SIP regulations apply)	
	SIP = CTG limits	1. Multiple zone incinerators and coating rooms
	SIP = Numerical limits	2. Thermal incineration with heat recovery
II.	Limiting emissions to the equivalent of an 85 percent reduction in the emissions from the average industry coating formulation of 40 percent solids and 60 percent VOC	2. Thermal incineration with heat recovery
III.	Limiting emissions to the equivalent of a 95 percent reduction in the emissions from the average industry coating formulation	3. Thermal incineration with heat recovery and coating rooms.

Small Line

Annual operating time	4,000 h
Annual coating time	2,780 h
Total metal processed	4.6 × 10^6 m^2/yr (50 × 10^6 ft^2/yr)
Metal	Aluminum, 0.46 m (18 in.) wide, 0.30 mm (0.012 in.) thick
Dry film thickness	prime coat, 0.0114 mm (0.00045 in.) each side
	top coat, 0.0114 mm (0.00045 in.) each side
Line speed	1.02 m/s (200 ft/min)
Ovens	1 each for prime coat and top coat
Oven exhaust temperature	316° C (600° F)

Medium Line

Annual operating time	4,000 h
Annual coating time	2,780 h
Total metal processed	14 × 10^6 m^2/yr (150 × 10^6 ft^2/yr)
Metal	Steel, 0.91 m (36 in.) wide, 0.43 mm (0.017 in.) thick
Dry film thickness	prime coat, 0.0114 mm (0.00045 in.) each side
	top coat, 0.0114 mm (0.00045 in.) each side
Line speed	1.5 m/s (300 ft/min)
Ovens	1 each for prime coat and top coat
Oven exhaust temperature	316° C (600° F)

Large Line

Annual operating time	4,000 h
Annual coating time	2,500 h
Total metal processed	28 × 10^6 m^2/yr (300 × 10^6 ft^2/yr)
Metal	Steel, 1.22 m (48 in.) wide, 0.48 mm (0.019 in.) thick
Dry film thickness	prime coat, 0.0114 mm (0.00045 in.) each side
	top coat, 0.0114 mm (0.00045 in.) each side
Line speed	2.5 m/s (500 ft/min)
Ovens	1 each for prime coat and top coat
Oven exhaust temperature	316° C (600° F)

Figure 8-2. List of parameters for model coil coating lines.

TABLE 8-8. KEY PARAMETERS FOR CONTROL OPTION 1: MULTIPLE ZONE INCINERATORS AND COATING ROOMS

	Line size		
Parameter	Small	Medium	Large
Oven exhaust temperature	316° C (600° F)	316° C (600° F)	316° C (600° F)
Exhaust volume, each oven	2.4 m^3/s (5,000 scfm)	4.7 m^3/s (10,000 scfm)	9.4 m^3/s (20,000 scfm)
Effectiveness of solvent capture	100 percent	100 percent	100 percent
Effectiveness of solvent destruction	64 percent	64 percent	64 percent
Average solvent input reaching oven	0.016 ℓ/s (15.1 gal/h)	0.048 ℓ/s (45.4 gal/h)	0.11 ℓ/s (101 gal/h)
Average heat released by solvent combustion	720 kW (2.5 MM Btu/h)	2,200 kW (7.4 MM Btu/h)	4,700 kW (16 MM Btu/h)
Electric power required above that of standard ovens	Approx. 0	Approx. 0	Approx. 0

MM Btu = million Btu/h.

TABLE 8-9. KEY PARAMETERS FOR CONTROL OPTION 2: THERMAL INCINERATION WITH HEAT RECOVERY

Parameter	Line size		
	Small	Medium	Large
Oven exhaust temperature	316° C (600° F)	316° C (600° F)	316° C (600° F)
Incineration temperature	760° C (1,400° F)	760° C (1,400° F)	760° C (1,400° F)
Exhaust volume, each oven	2.4 m^3/s (5,000 scfm)	7.1 m^3/s (15,000 scfm)	15.F m^3/s (33,000 scfm)
Primary heat exchanger duty	1,000 kW (3.5 MM Btu/h)	2,900 kW (10 MM Btu/h)	6,700 kW (23.MM Btu/h)
Secondary heat exchanger duty	1,800 kW (6.3 MM Btu/h)	5,600 kW (19 MM Btu/h)	12,000 kW (42 MM Btu/h)
Effectiveness of solvent capture	90 percent	90 percent	90 percent
Effectiveness of solvent destruction in incinerator	95 percent	95 percent	95 percent
Average solvent input reaching oven	.014 ℓ/s (13.6 gal/h)	.043 ℓ/s (40.9 gal/h)	.096 ℓ/s (90.0 gal/h)
Average heat released by solvent combustion	970 kW (3.3 MM Btu/h)	2,900 kW (9.9 MM Btu/h)	6,400 kW (22 MM Btu/h)
Electric power required above that of standard ovens	106 kW	225 kW	510 kW
Volume of preheated air to ovens	4.1 m^3/s (8,600 scfm)	12 m^3/s (26,000 scfm)	27 m^3/s (58,000 scfm)
Temperature of preheated air to ovens	382° C (720° F)	382° C (720° F)	382° C (720° F)

MM Btu/h = million Btu/h.

TABLE 8-10. KEY PARAMETERS FOR CONTROL OPTION 3: THERMAL INCINERATION WITH HEAT RECOVERY AND COATING ROOMS

Parameter	Line size		
	Small	Medium	Large
Oven exhaust temperature	316° C (600° F)	316° C (600° F)	316° C (600° F)
Incineration temperature	760° C (1,400° F)	760° C (1,400° F)	760° C (1,400° F)
Exhaust volume, each oven	2.4 m^3/s (5,000 scfm)	7.1 m^3/s (15,000 scfm)	15.6 m^3/s (33,000 scfm)
Primary heat exchanger duty	1,000 kW (3.5 MM Btu/h)	2,900 kW (10 MM Btu/h)	6,700 kw (23 MM Btu/h)
Secondary heat exchanger duty	1,800 kW (6.3 MM Btu/h)	5,600 kW (19 MM Btu/h)	12,000 kW (42 MM Btu/h)
Effectiveness of solvent capture	100 percent	100 percent	100 percent
Effectiveness of solvent destruction in incinerator	95 percent	95 percent	95 percent
Average solvent input reaching oven	0.16 ℓ/s (15.1 gal/h)	.048 ℓ/s (45.4 gal/h)	0.11 ℓ/s (101 gal/h)
Average heat released by solvent combustion	1,100 kW (3.7 MM Btu/h)	3,200 (11 MM Btu/h)	7,000 kW (24 MM Btu/h)
Electric power required above that of standard ovens	106 kW	225 kW	510 kW
Volume of preheated air to ovens	4.1 m^3/s (8,600 scfm)	12 m^3/s (26,000 scfm)	27 m^3/s (58,000 scfm)
Temperature of preheated air to ovens	382° C (720° F)	382° C (720° F)	382° C (720° F)

MM Btu/h = million Btu/h.

in the control device). Tables 8-8, 8-9, and 8-10 list important parameters for the three control options.

By virtue of its having the lowest capital and operating costs, Control Option 1 is the control option applied to CTG limits in this analysis. Option 1 involves the use of multiple incinerators as integral parts of the curing ovens. Fumes from the various oven zones are recycled through these incinerators in such a manner that solvent destruction is achieved before the exhaust leaves the ovens. These systems, in effect, incinerate a portion of the total gas flow in the ovens. With this control technique, a solvent destruction level of 64 percent is near the maximum that can consistently be obtained. Therefore, coating rooms are required in order to achieve maximum percent capture of solvents. The costs of coating rooms are included in the capital costs of this control option.

Control Option 2 is thermal incineration with primary and secondary heat recovery, resulting in 90 percent solvent capture and 95 percent solvent destruction. Figure 8-3 is a schematic diagram of a model coil coating line with such a control system. The effectiveness of the primary heat exchanger is limited to an average of 36 percent in order that the temperature of the gas stream entering the incinerator be no greater than 482° C (900° F) for safety reasons. The secondary exchanger is 60 percent effective, which is a relatively high level of effectiveness for an air-to-air exchanger, and is offered by a number of vendors as standard equipment. The use of these heat exchangers reflects the rapidly growing trend in the industry toward heat recovery systems.

Control Option 3 is thermal incineration with heat recovery, as in Option 2, with the addition of coating rooms. Solvent destruction is 95 percent complete, and solvent capture is assumed to be 100 percent effective. With reference to the model coil coating line diagrammed in Figure 8-3, the addition of enclosures around the two coating areas would make the "solvent loss" streams equal to zero and would increase the solvent available for combustion in the incinerator over that of Option 2.

Several variations on the above incineration schemes with heat recovery are available to the industry. These include the use of multiple zone incinerators followed by an afterburner and the use of thermal incineration with regenerative heat recovery.

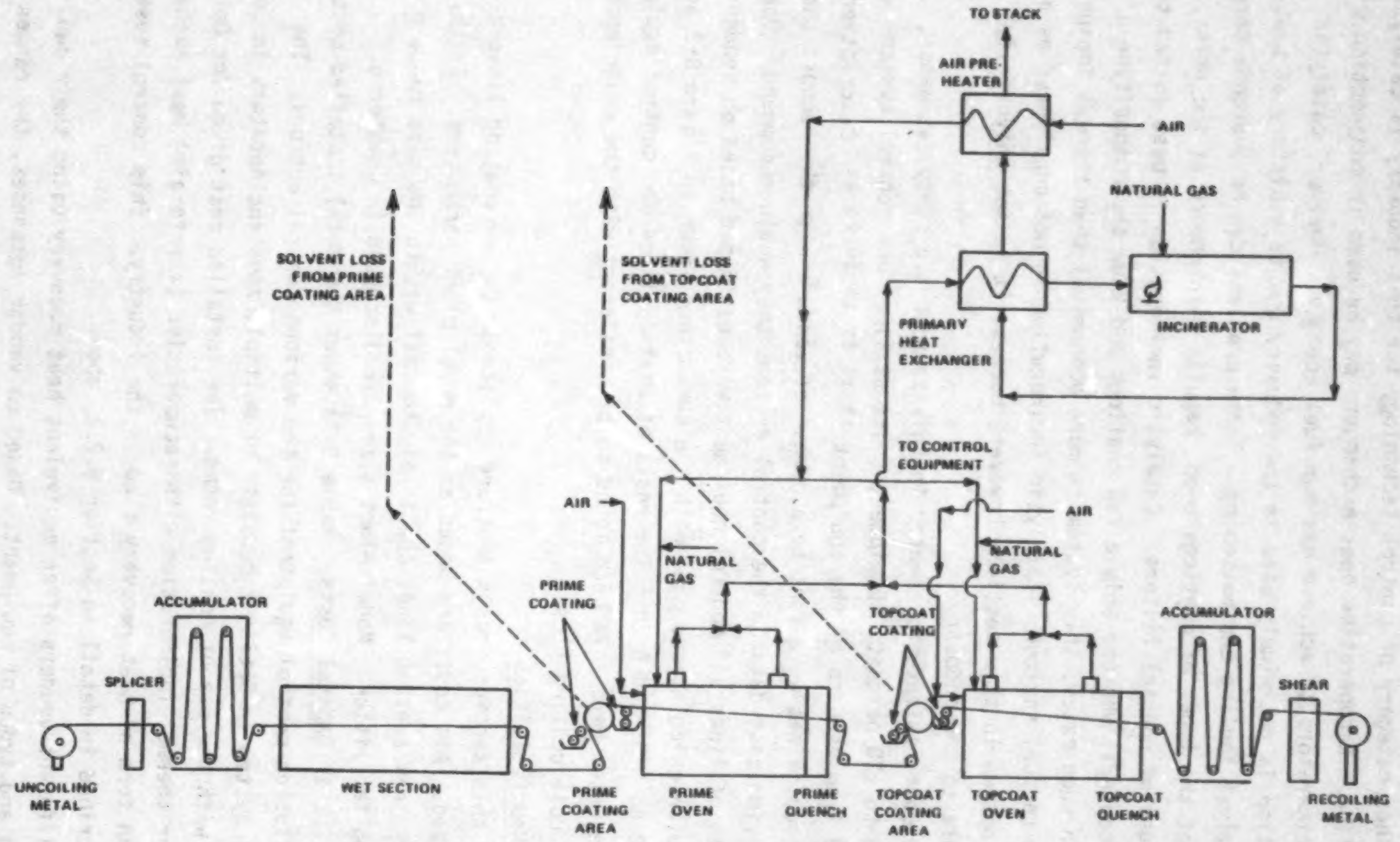
TO STACK
AIR PRE-HEATER
AIR
NATURAL GAS
INCINERATOR
PRIMARY HEAT EXCHANGER
SOLVENT LOSS FROM PRIME COATING AREA
SOLVENT LOSS FROM TOPCOAT COATING AREA
TO CONTROL EQUIPMENT
AIR
AIR
NATURAL GAS
NATURAL GAS
PRIME COATING
TOPCOAT COATING
ACCUMULATOR
SPLICER
ACCUMULATOR
SHEAR
UNCOILING METAL
WET SECTION
PRIME COATING AREA
PRIME OVEN
PRIME QUENCH
TOPCOAT COATING AREA
TOPCOAT OVEN
TOPCOAT QUENCH
RECOILING METAL

Figure 8-3. Schematic diagram of a model coil coating line with thermal incineration and primary and secondary heat recovery (Control Option 2).

Another category of control technology for this industry is catalytic incineration. Recuperative heat exchangers may be used in conjunction with these incinerators to achieve maximum fuel economy. However, catalytic incineration is not widely used in the industry due to a history of problems with catalyst fouling and poisoning. These problems can be overcome through control of the types of coatings used, regular maintenance of the units, and the use of special filters. Catalytic incineration is best suited to captive coaters, who use only a few coatings and know the composition of each. In such cases, this system is more economical than thermal incinerators due to fuel savings. Catalytic incineration is not considered as a control option in this section, however, because it is not universally applicable to the industry.

The cost estimates presented in this section are study estimates, accurate to ±30 percent. Equipment costs of lines and control systems were obtained from vendors of the equipment.[15] [16] [17] [18] [19] [20] [21] Descriptions of the model lines were sent to a number of vendors with the request that they provide cost data on the control systems they would recommend. Operating costs of lines and control equipment were estimated based on vendor data and on calculations made with the parameters shown in Figure 8-2 and Tables 8-8, 8-9, and 8-10. The costs of coating lines and control equipment presented here have been found to be consistent with the experience of various coil coating firms.

8.2.2 New Facilities

In this section, costs that are applicable to new coating lines are summarized. All costs are based on the model plant parameters. In this industry, new coating lines are likely to fall within the size range of existing facilities. Model plant sizes are discussed in Chapter 6.

8.2.2.1 Capital Costs. Table 8-11 shows the total installed costs of air pollution control equipment for the various control options. The control system in Option 1 consists of multiple zone incinerators in combination with the use of coating rooms. The installed cost given for Option 2 is for thermal incineration with recuperative (air-to-air) heat exchangers, a common form of heat recovery used in the industry. This control system is described in detail in Section 8.2.1, above.

Different vendors offer equivalent heat recovery using their own designs and types of equipment. Based on vendor responses, the ranges of

TABLE 8-11. CAPITAL COSTS OF CONTROL OPTIONS

Control option	Percent overall solvent destruction	Size model line	Installed cost, $1,000s
1. Multiple zone incinerators and coating rooms	64	Small	214
		Medium	289
		Large	405
2. Thermal incineration with heat recovery	85	Small	278
		Medium	548
		Large	1,178
3. Thermal incineration with heat recovery and coating rooms	95	Small	388
		Medium	680
		Large	1,322

installed capital costs for systems using thermal incineration with primary heat recovery (36 percent effectiveness) and secondary heat recovery (60 percent effectiveness), or at least equivalent heat recovery, are approximately as follows: small model line, $260,000 to $420,000; medium model line, $490,000 to $740,000; and large model line, $680,000 to $1,400,000. Because of the high air flow rates in the large model line, most vendors recommend the use of two incinerators, one for each oven. The costs of control for the large line thus include two incinerators plus heat recovery systems. The total installed costs shown in Table 8-11 were determined from equipment prices with component capital cost factors.[22] Table 8-12 shows the component capital cost factors used in this analysis.

Most vendors provide cost information for a 90 percent control level. Capital costs for the systems designed to deliver 95 percent solvent destruction are estimated to be 10 percent greater than the costs for systems designed to deliver 90 percent solvent destruction. Equipment vendors indicate that, for some lines, no modification to their standard control systems would be required to achieve 95 percent control. However, in order to guarantee 95 percent in every situation, a larger incineration chamber and/or special seals on the heat exchangers may be required. Based on discussions with vendors and on the use of standard cost/capacity correlations, the equipment cost of the incinerator alone would increase 20 to 30 percent for the required increase in residence time from approximately 0.3 second to 0.4 or 0.5 second.[23] [24] This would result in an increase in the cost of the entire system of approximately 10 percent. This factor was applied to the capital costs of systems for 90 percent destruction to arrive at the cost of systems for 95 percent destruction.

8.2.2.2 Annualized Costs. In this section, the annualized costs of the control options are discussed. These costs include annualized capital costs and operating costs for electricity, fuel, labor, and maintenance.

Table 8-13 shows some basic assumptions made in the cost calculations. Additional assumptions are that the control devices operate at preset temperatures and air flow rates throughout the 4,000 hours annual operating time and that the devices use no fuel during nonoperating hours. The latter assumption is made for ease in calculation, with the realization that a firm operating two shifts per day might choose to use a low-fire mode at night to protect the incinerator and heat exchangers and prevent

TABLE 8-12. COMPONENT CAPITAL COST FACTORS USED IN CALCULATING TOTAL INSTALLED COSTS

Type of cost	Component capital cost factor
Basic equipment cost	1.00
Installation direct costs	
Foundations and supports	0.08
Erection and handling	0.14
Electrical	0.04
Piping	0.02
Insulation	0.01
Painting	0.01
Freight	0.05
Installation indirect costs	
Engineering and supervision	0.10
Construction and field expense	0.05
Construction fee	0.10
Startup	0.02
Performance test	0.01
Contingencies	0.03
Total	1.66

TABLE 8-13. CALCULATION OF ANNUALIZED COSTS OF AIR POLLUTION CONTROL SYSTEMS

Cost component	Basis of calculation
Operating factor	16 h/d 250 d/yr 4,000 h/yr
Operation and maintenance	5 percent of installed cost
Utilities	
Electricity	$.04/kWh
Natural gas	$2.84/GJ ($3.00/MM Btu)
Capital recovery factor[a]	0.174

[a] A 20-year equipment life and a 12 percent interest rate are assumed for the capital recovery factor (CRF). The CRF also includes 0.02 for administration and overhead and 0.02 for taxes and insurance.

MM Btu/h = million Btu/h.

lengthy warm-up times. The operating temperature to achieve 95 percent solvent destruction is taken as 760° C (1,400° F) in the thermal incinerators.[23] [25]

Table 8-14 summarizes annual operating costs for the control options. The estimates of operating costs for Options 2 and 3 in this analysis tend to be somewhat higher than the costs that the most energy-conscious firm could achieve with the same equipment. This is primarily due to fuel costs. The control equipment at many existing plants is operated at preset temperatures and gas flows as assumed in this analysis. However, as energy conservation becomes more of a necessity, the use of low-fire modes during extended noncoating periods and during oven turndown modes, when possible, may increase. Such practices would tend to keep operating costs below those shown here.

Tables 8-15 through 8-17 present annualized capital and operating costs for air pollution control systems. Three levels of overall solvent destruction are evaluated for facilities that use solvent-borne coatings: 64 percent, 85 percent, and 95 percent.

The operating costs of the control systems in Tables 8-15 through 8-17 demonstrate the economic value of heat recovery equipment. The fuel requirement of each control system is less than the requirement of a line without controls. In the medium and large plants, the fuel savings cause the direct cost (operating cost) of each system to be negative, i.e., a savings. For any given new coating line, a particular design of the heat recovery scheme may offer the most cost-effective emission control. Firms building new lines generally consider several designs before deciding on the best one for their applications. Several plants are using regenerative heat recovery systems that are reported by the vendor to yield a net cost savings for almost any size line. Other firms are using direct recycle of incinerator exhaust or recycle of oven exhaust through oven burners. There are many variations on thermal incineration with heat recovery in the industry.

8.2.2.3 Cost Effectiveness. The overall cost effectiveness of control options is presented in Tables 8-15 through 8-17. These figures give the annual cost or savings associated with a control system per unit VOCs removed.

TABLE 8-14. ANNUAL OPERATING COSTS OF CONTROL OPTIONS

Control option	Model line size	Annual operating costs, $1,000s			
		Electricity	Fuel	Labor, maintenance, materials	Total
1.	Small	0	(25)	10	(15)
	Medium	0	(143)	14	(129)
	Large	0	(304)	20	(284)
2.	Small	17	(25)	14	6
	Medium	36	(83)	28	(19)
	Large	82	(178)	60	(36)
3.	Small	17	(28)	20	9
	Medium	36	(93)	35	(22)
	Large	82	(198)	67	(49)

TABLE 8-15. ANNUALIZED COST OF VOC CONTROL OPTIONS FOR SMALL MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Overall effectiveness of VOC reduction		Annualized capital costs, $1,000s	Direct cost (savings), $1,000s	Total annualized cost (savings), $1,000s	Overall cost (savings)/unit VOC removal	
		Mg/yr	ton/yr				$/Mg	$/ton
1. Multiple zone incinerators and coating rooms	64	176	194	37	(15)	22	120	110
2. Thermal incineration with heat recovery	85	235	259	48	6	54	230	208
3. Thermal incineration with heat recovery and coating rooms	95	261	288	68	9	77	295	267

[a] Facilities that use waterborne coatings were not considered for add-on controls.

TABLE 8-16. ANNUALIZED COSTS OF VOC CONTROL OPTIONS FOR MEDIUM MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Overall effectiveness of VOC reduction		Annualized capital costs, $1,000s	Direct cost (savings), $1,000s	Total annualized cost (savings), $1,000s	Overall cost (savings)/unit VOC removal	
		Mg/yr	ton/yr				$/Mg	$/ton
1. Multiple zone incinerators and coating rooms	64	530	584	50	(129)	(79)	(149)	(135)
2. Thermal incineration with heat recovery	85	708	780	95	(19)	76	107	97
3. Thermal incineration with heat recovery and coating rooms	95	787	866	118	(22)	96	122	111

[a] Facilities that use waterborne coatings were not considered for add-on controls.

TABLE 8-17. ANNUALIZED COSTS OF VOC CONTROL OPTIONS FOR LARGE MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Overall effectiveness of VOC reduction		Annualized capital costs, $1,000s	Direct cost (savings), $1,000s	Total annualized cost (savings), $1,000s	Overall cost (savings)/unit VOC removal	
		Mg/yr	ton/yr				$/Mg	$/ton
1. Multiple zone incinerators and coating rooms	64	1,060	1,168	70	(284)	(214)	(202)	(183)
2. Thermal incineration with heat recovery	85	1,411	1,556	205	(36)	169	120	109
3. Thermal incineration with heat recovery and coating rooms	95	1,568	1,729	230	(49)	181	115	105

[a] Facilities using waterborne coatings were not considered for add-on controls.

Control Option 1, applicable only to lines needing 64 percent control, offers a net savings over the cost of standard coating lines for the medium and large model lines. This is because the use of multiple zone incinerators and coating rooms has a relatively low capital cost above that of the basic lines (without emission controls) for larger plants yet allows recovery of substantial heat from the solvent.

Tables 8-18 through 8-20 show the marginal cost per unit VOCs removed for various control alternatives in achieving NSPS levels of control. The marginal cost in achieving NSPS limits over CTG limits is the difference in total annualized cost between the CTG control option and the NSPS option being considered. For the medium and large size plants, the annualized cost of the CTG option is negative; that is, it is a savings over the standard line without controls, as seen in Tables 8-15 through 8-17. Thus the marginal cost per unit VOCs removed is higher for the medium and large model lines than for the small line.

The marginal costs per unit VOCs removed given in Tables 8-18 through 8-20 (e.g., the case of going from Control Option 2 to Control Option 3 for small and medium plants) are generally higher than the corresponding overall cost effectiveness values given in Tables 8-15 through 8-17. This is primarily due to the increase in capital requirements to achieve a modest reduction in emissions. The large plant shows a relatively low marginal cost in this case because of proportionally lower capital costs per unit VOCs removed. In going from the CTG control system (Option 1) to the NSPS control system (Options 2 or 3), the high marginal costs are due to a combination of major increases in capital costs and substantially higher fuel requirements.

8.2.2.4 Base Cost of Facility. This section presents the base cost and operating costs of new coil coating facilities. These costs can be compared to the cost of controls allocable to NSPS to determine the economic feasibility of new regulations. The analysis contains costs for each size model plant.

The major capital expenses for a new coil coating plant are for mechanical equipment and ovens for the line itself, installation of equipment, and materials and construction of a large factory building. These costs are summarized in Table 8-21. All information in Table 8-21 was

TABLE 8-18. MARGINAL COST EFFECTIVENESS OF NSPS ABOVE SIP REGULATIONS FOR SMALL MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Incremental effectiveness of VOC removal compared with SIP regulations Mg/yr(ton/yr)[b]		Incremental annualized cost attributable to NSPS, $1,000s		Marginal cost per unit of VOC removal $/Mg ($/ton)	
		States using CTG limit	States using numerical limits	States using CTG limits	States using numerical limits	States using CTG limits	States using numerical limits
2. Thermal incineration with heat recovery	85	59 (65)	~0 (~0)	32	0	540 (490)	-
3. Thermal incineration with heat recovery and coating rooms	95	85 (94)	26 (29)	55	23	650 (590)	880 (790)

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[a] Facilities that use waterborne coatings were not considered for add-on controls.

[b] The difference between SIP emissions and NSPS emissions expressed on an annual basis.

TABLE 8-19. MARGINAL COST EFFECTIVENESS OF NSPS ABOVE SIP REGULATIONS FOR MEDIUM MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Incremental effectiveness of VOC removal compared with SIP regulations Mg/yr(ton/yr)[b]		Incremental annualized cost attributable to NSPS, $1,000s		Marginal cost per unit of VOC removal $/Mg ($/ton)	
		States using CTG limit	States using numerical limits	States using CTG limits	States using numerical limits	States using CTG limits	States using numerical limits
2. Thermal incineration with heat recovery	85	178 (196)	~0 (~0)	155	~0	870 (790)	-
3. Thermal incineration with heat recovery and coating rooms	95	257 (282)	79 (86)	175	20	680 (620)	250 (230)

[a] Facilities that use waterborne coatings were not considered for add-on controls.

[b] The difference between SIP emissions and NSPS emissions expressed on an annual basis.

TABLE 8-20. MARGINAL COST EFFECTIVENESS OF NSPS ABOVE SIP REGULATIONS FOR LARGE MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Incremental effectiveness of VOC removal compared with SIP regulations Mg/yr(ton/yr)[b]		Incremental annualized cost attributable to NSPS, $1,000s		Marginal cost per unit of VOC removal $/Mg ($/ton)	
		States using CTG limit	States using numerical limits	States using CTG limits	States using numerical limits	States using CTG limits	States using numerical limits
2. Thermal incineration with heat recovery	85	351 (388)	~0 (~0)	383	~0	1,110 (1,000)	-
3. Thermal incineration with heat recovery and coating rooms	95	508 (561)	157 (173)	395	12	780 (710)	80 (70)

[a] Facilities that use waterborne coatings were not considered for add-on controls.

[b] The difference between SIP emissions and NSPS emissions expressed on an annual basis.

TABLE 8-21. CAPITAL COSTS OF NEW COIL COATING FACILTIES

Cost item	Costs for each size model line, $1,000s		
	Small	Medium	Large
Mechanical equipment--line	2,700	4,000	5,150
Ovens	630	800	1,090
Installation of mechanical equipment and ovens	1,110	1,600	2,080
Total basic line cost	4,440	6,400	8,320
Building cost	2,870	3,870	5,200
Total facility cost less control equipment	7,310	10,270	13,520
Total facility cost, including control equipment, to meet Control Options 1, 2, and 3[a]			
Control Option 1--64 percent overall destruction	7,520	10,560	13,920
Control Option 2--85 percent overall destruction	7,590	10,820	14,700
Control Option 3--95 percent overall destruction	7,700	10,950	14,840

[a] Applicable only to lines that use solvent-borne coatings.

obtained from vendors and other persons responsible for estimating costs of new lines.[15 16 21 26 27] In Table 8-21, four significant figures are used only to demonstrate differences between costs with and without emission controls.

Installation costs are the most variable of the costs shown. These are affected by geographic location of the new facility and the local cost of labor. A factor of 33 percent of equipment cost is assumed for the installation cost of mechanical equipment.[15 26]

Since few lines have been built exclusively for the use of waterborne coatings, there are few cost data available on these lines at the present time. However, most of the mechanical equipment and the structure for a plant that uses such lines would be similar to those of a plant with lines built exclusively for the use of solvent-borne coatings. As previously discussed, the average oven size and air flow on lines that use waterborne coatings are assumed to be the same as those on lines that use solvent-borne coatings. Therefore, the costs of model lines that use waterborne coatings may also be taken from Table 8-21.

New model coating facilities would require approximately the following shop areas: small line, 6,690 m^2 (72,000 ft^2); medium line, 9,290 m^2 (100,000 ft^2); and large line, 12,800 m^2 (138,000 ft^2). The building costs in Table 8-21 reflect a cost of \$377/m^2 (\$35/ft^2) plus an allowance for a ceiling-mounted crane.[15 26 27] Building costs are high in this industry because of the amount of structural steel required.

In estimations of annual operating costs of model coating facilities, it was assumed that each facility provides coating services for customers and does not actually purchase the metal. Table 8-22 gives annual operating costs for the model plants. Costs of coatings are by far the greatest operating expenses for coil coaters. Annual coating costs for the model facilities are estimated with a figure of \$2.37/m^2 (\$.022/ft^2) coated. This figure reflects the use of a relatively inexpensive, commonly used coating (a polyester, for example) at the film thickness used in the model plants. Most coating facilities use a variety of coatings and adjust their charge to the customer to reflect the cost of the coatings.

Electrical costs in Table 8-22 were calculated with a figure of 0.26 kWh/m^2 (0.024 kWh/ft^2) of metal coated. The electrical costs of

TABLE 8-22. ANNUAL OPERATING COSTS OF MODEL COIL COATING LINES WITHOUT EMISSION CONTROL EQUIPMENT

Model line size	Annual operating costs, $1,000s					
	Electricity	Fuel	Labor	Maintenance and repairs	Materials	Total
Small	31	88	360	370	1,100	1,900
Medium	110	270	520	510	3,300	4,700
Large	210	590	670	680	6,600	8,800

operating coil coating lines vary from less than 0.19 kWh/m^2 (0.018 kWh/ft^2) coated to greater than 0.31 kWh/m^2 (0.029 kWh/ft^2) coated, depending on line size, line speed, and type of equipment.[26 28] Fuel costs are based on the use of ovens with no solvent destruction or heat recovery. The costs of electrical energy and fuel energy are given in Table 8-14. Labor costs in Table 8-22 reflect the following: small plant, 19 employees; medium plant, 28 employees; and large plant, 36 employees. These numbers exclude maintenance personnel, whose salaries are included in the maintenance and repair costs. These costs are estimated at 5 percent of the total installed costs of the facilities without air pollution control equipment. All labor is assumed to cost $9 per hour. The number of employees in each plant reflects a shop worker to administrative worker ratio of approximately 3 to 1.

8.2.3 Modified/Reconstructed Facilities

As discussed in Chapter 5, most modifications to coil coating lines are made either to increase the production rate or to conserve fuel energy. In the past, a number of plants have achieved an increase in line speed of approximately 20 percent by replacing drive motors and gears and by changing the electrical controls on the line.[29] Frequently, no modification to the ovens was required in such cases. Today, the cost of modifying a line in this manner would be on the order of $100,000 to $200,000.

Since an increase in line speed would result in increased emissions, such a modification would bring a facility under NSPS regulations. For purposes of estimating the economic impact of the regulations on a facility undergoing modifications, the installed capital costs of emission control equipment given in this chapter, multiplied by a factor of 1.3, may be used. The 30 percent increase in capital costs is intended to allow for additional direct costs of ducting, structural work, and electrical work and for additional indirect costs of engineering and construction. These costs are very much site specific. The capital costs of retrofitting emission control systems vary from less than 20 percent greater to several hundred percent greater than the costs of such equipment on new lines. A figure of 30 percent represents the typical case where no major design or installation problems are encountered in the retrofitting process.

Capital and operating expenses were analyzed for coil coating lines (in the size range of the model lines) that undergo modifications to increase their production rate by 20 percent. While this is by no means the only kind of modification expected in the industry, it is believed to be a reasonable example of modifications that may occur. An existing line meeting CTG limits by Control Option 1 would be required to install additional emission control equipment in order to meet NSPS requirements. Thermal incinerators are generally used in combination with Control Option 1 systems to achieve better emission control. The operating temperatures of the afterburner can be significantly less than 760° C (1,400° F) for most solvents.[15]

For the purpose of estimating the costs of additional emission control needed to meet NSPS, the following system is used. On each model line, an afterburner with a primary heat exchanger is added to treat the exhaust flow from both ovens. The primary heat exchanger, with an effectiveness of 50 percent, is used to preheat oven exhaust gas with heat from the incinerator exhaust gas. Primary heat exchangers are used here because package units containing both incinerator and heat exchanger are available, and because their use here is in keeping with the level of heat recovery used in the analysis of new lines meeting NSPS requirements in Section 8.2.2. Secondary heat exchangers or air preheaters are not considered here (1) because significant heat recovery has already been achieved by the use of zone incinerators and a primary heat exchanger and (2) because afterburner temperatures are somewhat lower than those considered in Section 8.2.2. The operating temperatures of the add-on incinerators assumed here are 538° C (1,000° F) for 85 percent overall control and 649° C (1,200° F) for 95 percent overall control.

The capital costs of the incinerator systems with primary heat recovery for the model lines already having Control Option 1 are as follows: small line, $258,000; medium line, $426,000; large line, $671,000. The units are sized for actual flow rates at 649° C (1,200° F). The costs are corrected to current prices using Marshall and Swift equipment cost indices and a factor of 1.30 to account for the extra costs of retrofit equipment.

Operating costs of modified lines originally having CTG levels of emission control are described in Table 8-23. The table includes information on the additional operating costs of the model lines modified for a 20

TABLE 8-23. INCREASE IN ANNUAL OPERATING COSTS OF EXISTING LINES HAVING CTG CONTROL SYSTEMS DUE TO INCREASED PRODUCTION AND ADDITIONAL EMISSION CONTROL
($1,000s)

Size model line	Fuel	Electricity	Maintenance and repairs[a]	Materials	Labor	Total
A. Production						
Cost increase (savings) in existing portion of line due to 20 percent increase in production[b]						
Small	(4)	7	0	220	0	223
Medium	(12)	20	0	660	0	668
Large	(23)	41	0	1,320	0	1,338
B. Control						
Cost increase due to additonal control equipment needed to provide 85 percent overall control						
Small	23	5	13	0	0	41
Medium	37	10	21	0	0	68
Large	72	20	33	0	0	125
C. Control						
Cost increase due to additonal control equipment needed to provide 95 percent overall control						
Small	35	5	13	0	0	53
Medium	58	10	21	0	0	89
Large	114	20	33	0	0	167

[a] Includes the materials and labor associated with maintenance and repairs.

[b] To obtain total additional operating costs of a line due to increase in production and NSPS requirements, add the total production cost increase (A) to the total control cost increase for the appropriate NSPS level of control (B or C).

percent increase in line speed, without the additional afterburners. Costs are also presented that can be directly attributed to the additional control systems.

The above discussion of capital and operating costs refers to the situation in which an existing line with CTG levels of emission control is retrofitted with equipment to meet NSPS requirements for the regulatory alternatives requiring 85 and 95 percent overall control. In the case of a line currently having a system to provide 85 percent overall control (in States using numerical limits), the only regulatory alternative to consider is the alternative requiring 95 percent overall control. Since the system in Control Option 2 provides 85 percent overall control, it is assumed here that an existing facility in a State using numerical limits would need to add coating rooms to achieve 95 percent control. The installed costs of coating rooms, with a factor of 1.3 built in to allow for the difficulty of retrofitting the equipment, are as follows: small line, $143,000; medium line, $172,000; large line, $187,000. Additional operating costs due to the increased production and the additional emission control are summarized in Table 8-24. The fuel savings shown are due to the heat of combustion provided by the additional solvent oxidized to 95 percent destruction.

In actual practice, some existing facilities may be achieving 85 percent overall removal by other means, such as less efficient incinerators in combination with coating rooms. In such cases, the capital and operating expenses would be different (perhaps higher) than those presented here. For example, facilities may have to modify existing incinerators to increase the residence time of combustion chambers or to reduce leakage in heat exchangers. However, the costs presented in Table 8-24 represent those expected in typical cases.

8.3 OTHER COST CONSIDERATIONS

The purpose of this section is to summarize, to the extent possible, the cost impact of requirements imposed on the coil coating industry by other environmental regulations. Areas of other major regulations pertinent to the coil coating process include water pollution, occupational exposure to toxic substances by employees, and toxic substances control.

TABLE 8-24. INCREASE IN ANNUAL OPERATING COSTS OF EXISTING LINES HAVING 85 PERCENT CONTROL DUE TO INCREASED PRODUCTION AND ADDITIONAL (95 PERCENT OVERALL) EMISSION CONTROL TO MEET NSPS ($1,000s)

Size model line	Fuel	Electricity	Maintenance and repairs[a]	Materials	Labor	Total
A. Production						
Cost increase (savings) in existing portion of line due to 20 percent increase in production[b]						
Small	(5)	7	0	220	0	222
Medium	(15)	20	0	660	0	665
Large	(31)	41	0	1,320	0	1,330
B. Control						
Additional cost increase (savings) due to additional control equipment needed to provide 95 percent overall control						
Small	(4)	0	7	0	0	3
Medium	(11)	0	9	0	0	(2)
Large	(21)	0	9	0	0	(12)

[a] Includes the materials and labor associated with maintenance and repairs.

[b] To obtain total additional operating costs of a line due to increase in production and NSPS requirements, add the total production cost increase (A) to the total control cost increase (B).

8.3.1 The Clean Water Act

Coil coating facilities are generally subject to effluent discharge regulations imposed by the Federal Water Pollution Control Act Amendments of 1972,[30] as amended by the Clean Water Act of 1977, Public Law 95-217 (the Act). Basically, the Act requires that EPA develop effluent limitations for both new and existing facilities that discharge liquid effluent directly into navigable waters. New and existing facilities that discharge to publicly owned treatment works (POTWs) would be subject to new pretreatment standards. In addition, Section 307 (a) of the Act requires that the Administrator promulgate specific effluent guideline limitations for the toxic pollutants listed under Section 307 (a) (1) of the Act. Included in this listing are several of the solvents commonly used in the surface coating process.

Effluent discharges from coil coating facilities generally originate from the pretreatment ("wet") section of the plant. In the actual coating process, common industry practice entails the capture and reclaimation of cleanup solvent in lieu of effluent discharge. When a color change is made in a plant that uses solvent-borne coatings, the coating tray and coating rolls are cleaned with solvent. Excess solvent is drained from the coating pan, stored in drums, and shipped to a commercial recovery plant. Reclaimed solvent from the recovery plant is sold back to the coater for use in cleanup operations.

Estimates of compliance costs for Water Act regulations are not available for inclusion in this study. However, preliminary estimates indicate no expectation of plant closures due to the regulations, which are scheduled for proposal in September 1980.[31] New or existing sources that meet, or plan to meet, existing National Pollutant Discharge Elimination System (NPDES) standards would incur only minimal economic impact. However, sources that do not practice solvent recovery in the coating process may be subject to a more severe impact for water treatment systems.[31]

8.3.2 Occupational Exposure

The responsibility of regulating levels of emissions within the plant working area is that of the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA). OSHA is a part of the U.S. Department of Labor, and its responsibilities include final adoption of occupational exposure standards and enforcement of the standards through inspection of work places. NIOSH is an agency of the U.S. Department of Health, Education, and Welfare, and part of its charter is to provide regulation support information to OSHA.

OSHA has worker area standards for nearly 500 chemicals. These standards are very similar to the Threshold Limit Values (TLVs) designated by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH defines TLV as "concentrations of air-borne substances which represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect . . . . TLVs refer to time-weighted concentrations for a seven or eight hour workday and a forty hour work week." This same definition may be used for OSHA exposure standards. The TLVs for typical solvents used in the coil coating process are shown in Table 8-25.

Control of worker-area solvent concentrations is accomplished through containment, isolation, substitution, general ventilation, local exhaust ventilation, change of operating procedures, and administrative control. Many hooding techniques can be used and are discussed in the ACGIH Industrial Ventilation Manual.[32] Around a coating area, a hooding system combined with a containment system can be very effective in limiting employee solvent exposure levels. The cost of hood, ducting, and fan is expected to be a small percent of the total capital cost of a new coating line.

Another emission level constraint affecting the coil coater is the lower explosive limit (LEL) of solvents. Solvent explosions are not only a health and safety concern to the worker, they also are a great concern to insurers of coating equipment. Insurance companies require strict monitoring of solvent levels in equipment areas where such levels might approach the LEL.

The highest solvent levels are found in the drying ovens. Most coating systems are designed to maintain a concentration below 25 percent of the LEL in the ovens. Table 8-25 lists LEL values for typical solvents used in the coil coating industry. However, meeting the required levels of solvent concentration in this instance is a design concern rather than an added cost due to Federal regulation.

TABLE 8-25. THRESHOLD LIMIT VALUES (TLV) AND LOWER EXPLOSIVE LIMITS (LEL) OF TYPICAL SOLVENTS

	TLV		LEL	
Solvent	Mg/m^3	ppm	Vol %	$lb/10^3 ft^3$ [a]
Toluene	375	100	1.27	2.37
Xylene	435	100	1.0	2.32
n-Hexane	(1,800)[b]	(500)[b]	1.3	2.75
n-Heptane	(2,000)[b]	(500)[b]	1.0	2.40
Cyclohexane	1,100	300	1.31	2.8
Naphtha	NA	NA	0.81	2.16
Methyl acetate	610	200	4.1	7.45
Ethyl acetate	1,400	410	2.2	4.74
N-Butyl acetate	710	150	1.7	4.83
Acetone	2,400	1,000	2.15	3.04
Methyl ethyl ketone (MEK)	590	200	1.81	3.20
Methyl isopropyl ketone	700	200	1.4	3.54
Carbon tetrachloride	65[c]	10[c]	NA	NA
Methanol	260[c]	200[c]	6.0	4.70
Ethanol	1,900	1,000	3.3	3.72

[a] Calculated at 100° F.

[b] In the process of being changed.

[c] Can be potentially absorbed by the body through skin, eyes, or mucous membranes.

NA--not available.

8.3.3 Toxic Substances Control

The EPA Office of Toxic Substances has authority to regulate the manufacture, importation, processing, use, and disposal of chemical substances that pose unreasonable risk to health or the environment. This includes industries such as the paint and coating industries, which for the most part are processors of chemicals; i.e., they mix chemicals such as solvents to form paint.[33]

Several of the solvents currently in wide use throughout the industry are contained on the EPA Priority List of Toxic Substances. These substances, including toluene, are under active study by the Agency. Accordingly, future regulations may ban their use in manufacturing processes or may limit them to specific nonessential uses. However, the impact of such a regulation appears minimal.[34]

8.4 ECONOMIC IMPACT ANALYSIS

This section analyzes the economic impacts of the regulatory alternatives for new and modified facilities in the coil coating industry. Model plants of three capacities are used to represent typical new sources and typical existing sources that might undergo modification in the industry. The analysis in this section is based on the parameters and costs presented in Sections 8.2 and 8.3. Two baselines are used in estimating the economic impacts; these correspond to facilities in States that require a reduction in VOC emissions of 64 percent (designated as CTG areas) and to those in States that specify an 85 percent reduction in VOC emissions (designated as numerical limit areas).

The impacts of two regulatory alternatives are estimated in this section, only one of which applies to new and modified sources in numerical limit areas. Regulatory Alternative I is the no regulation, or No NSPS, case and would therefore have no impact on the industry. Regulatory Alternative II would require an 85 percent reduction in emissions and applies only to sources in CTG areas. Regulatory Alternative III would require a 95 percent reduction in emissions and applies to sources in CTG and numerical limit areas.

Three types of impacts are estimated. Price impacts are calculated with the assumption that all additional costs of the alternatives are passed forward to consumers of the coil coaters' services. Return on investment (ROI) impacts assume that these additional costs are absorbed by the coil coater--that is, that the product price does not change in the face of a cost increase. Finally, incremental capital requirements attributable to the regulatory alternatives are estimated. Section 8.4.1 contains a summary of these impacts for new and modified facilities. Section 8.4.2 discusses the structure and performance of the industry and provides a backdrop against which the estimated impacts can be interpreted. Section 8.4.3 describes the methodology used to estimate the impacts. Sections 8.4.4 and 8.4.5 present the estimated impacts for new and modified facilities, respectively.

8.4.1 Summary

The regulatory alternatives would have a smaller impact on new sources than on existing facilities that undergo modification. These impacts are more severe for new and modified sources in CTG areas than for those in numerical limit areas. In addition, the regulatory alternatives are likely to affect the toll coater more than the captive, or subsidiary, coater, who is a part of an integrated company.

Estimated price impacts for new facilities range from 0.2 to 4.1 percent. The larger price impacts fall on firms in the CTG areas and range from 1.0 to 4.1 percent compared with those for sources in numerical limit areas, which range from 0.2 to 0.8 percent. The decline in the baseline ROI of 12 percent is estimated to range from 0.4 to 2.4 percentage points for facilities constructed in CTG areas as opposed to a decline ranging from 0.1 to 0.3 percentage points for new sources in numerical limit areas. The largest incremental capital outlay for firms in CTG areas represents 6.6 percent of the baseline (Alternative I) outlay compared with a maximum increase of 1.4 percent for firms in numerical limit areas. Even though the regulatory alternatives affect facilities in CTG areas more than those in numerical limit areas, no competitive advantage is gained or lost because coil coating firms serve local markets rather than a national one. In effect, this means that firms in CTG areas are not in competition with firms in numerical limit areas.

The impacts for existing sources that undergo modification are more severe than those reported above for new sources; again, lines in CTG areas are affected more than those in numerical limit areas. The price impacts for the former range from 20.2 to 45.5 percent; those for the latter range from 2.0 to 15.0 percent. An ROI does not exist that would allow a modified facility in a CTG area to maintain the baseline (No NSPS) price of its coating services. The baseline ROI of a facility in a numerical limit area would decline by 6.1 to 11.9 percentage points. The incremental capital required if a modification is undertaken explains the size of these impacts. It ranges from 258 to 336 percent of the baseline investment for facilities in CTG areas, or 94 to 143 percent for modified sources in numerical limit areas.

A distinction must be drawn in the interpretation of these results as they are applied to toll versus captive coaters. For the toll coater, whose product is a service (namely, the coating of a steel or aluminum coil for a price), the results stand. A captive coater, however, is usually part of a vertically integrated firm--a steel or aluminum producer, for example. In this case, the regulatory alternatives would increase the cost of an input (the coated coil) used in the manufacture of some final product--for example, aluminum siding or rain-carrying equipment. Because the cost of this input represents only a fraction of the cost of all inputs used to manufacture the final product, the actual increase in the product price would be less than the "price" increases reported above. Thus, the toll coater might suffer greater impacts than the captive coater, whose parent company might be more interested in an assured supply of coated coils than in the price *per se* of the coater's services.

8.4.2 Economic Conditions in the Industry

The purpose of this section is to provide a perspective from which to interpret the economic impacts presented in Sections 8.4.4 and 8.4.5. These impacts are based on representative model plants, which are engineering constructs, rather than on actual plants and firms in the industry. The information in this section, then, supplements the model plant analysis by relating it to actual conditions facing the industry. Section 8.4.2.1 describes the structure of the coil coating industry. Section 8.4.2.2 analyzes the financial performance of the industry and presents an estimate of the weighted average cost of capital, which is used in the calculation of the economic impacts.

8.4.2.1 Industry Structure. Production in the coil coating industry, as noted in Section 8.1.1, is not heavily concentrated. Historical data on concentration ratios for the metal coating and allied services industry (of which coil coating is a part) are presented in Table 8-26. In each case the concentration ratio has been derived by calculating the ratio of the value of shipments of the 4, 8, 20, and 50 largest firms to the value of shipments for all firms in the industry. It should be emphasized that coil coating is only a part of this industry, and the concentration ratios may not reflect the degree of concentration existing among coil coaters. The total value of shipments by coil coating firms accounted for 17.2 percent of the total value of shipments for the metal coating and allied services industry in 1972 and for 18.9 percent in 1977.[35] Data for a more complete analysis of concentration ratios for the coil coating industry are not currently available.

The evidence suggests that firms exhibit economies of scale in production. As stated in Section 8.1.1, as well as in other industry studies, production is capital intensive and continuous; high-volume production is a significant operating characteristic.[36] There is no evidence, however, that these economies of scale restrict the entry of new firms into the industry. Expansion within the industry, as discussed in Section 8.1.2.1, consists primarily of the modification of existing lines (to increase the line speed) and the construction of new lines by existing firms.

Vertical and horizontal integration may be more important as barriers to entry into the industry. As Table 8-1 indicates, the majority of coil coating firms are subsidiaries of larger organizations. As a result, the cost of capital may be lower than that for independent (nonsubsidiary) coaters. (A large, publicly traded firm has access to more sources of capital than does a privately owned, or independent, coater. Such sources include issuing more shares of common stock, financing out of retained earnings, issuing notes or bonds, and borrowing from a bank. The privately owned coater can tap only two of these sources: earnings and bank borrowing. The publicly traded firm, then, has more flexibility in determining the financing mix, and thus the cost of financing, than does the independent coater.) Many nonsubsidiary firms are large metal processing and manufacturing enterprises, who may therefore be less concerned with the market

TABLE 8-26. CONCENTRATION RATIOS IN THE METAL COATING AND ALLIED SERVICES INDUSTRY[37]

Year	Value of shipments (%) accounted for by largest firms			
	4 firms	8 firms	20 firms	50 firms
1963	17	26	39	54
1967	18	26	37	50
1972	15	23	36	49

demand for coil coating services. Both characteristics imply, at least qualitatively, that a new market entrant would potentially face higher capital costs as well as less certain demand and would thus be less likely to enter the market in response to otherwise favorable profit conditions.

As indicated in Table 8-6, the coil coating industry has experienced historically high growth rates. This trend is expected to continue through 1985 and will take place through increased sales to the transportation industry as well as expansion of newer markets such as the large appliance industry. However, growth is expected to be achieved by using existing capacity more fully, by modifying existing lines, and by the construction of new lines by existing manufacturers.

In light of the industry's economic structure, there are several qualitative implications regarding the impacts of the regulatory alternatives. If compliance requires significant increases in capital costs, the higher interest rates paid by the nonsubsidiary firms will increase their costs of production, making them less competitive than the subsidiary firms.

8.4.2.2 Industry Performance. Data on a variety of financial statistics for the coil coating industry for the period 1976-1978 are presented in Table 8-27. These statistics were compiled from data on 29 firms (see Section 8.6). The industry's financial position appears to have been relatively satisfactory over the 3-year period.

The ratio of current assets to current liabilities fell slightly between 1976 and 1978 but remained above 2.0, indicating an ability to meet all short-term obligations. Long term debt to total capitalization in the industry declined from 34 percent in 1976 to 31 percent in 1978; the industry is not burdened with excessive debt, and the average coil coating firm should be able to finance at least a part of new investment through the bond market, usually a less costly option than financing out of equity. The ratios of sales to inventory and sales to receivables fluctuated sharply between 1977 and 1978. The sales-to-inventory ratio more than doubled, suggesting that the industry reduced the value of its assets held in the form of inventories relative to sales, an indicator that the industry is not carrying excessive inventory. The ratio of sales to receivables fell, however, indicating that the industry's customers were not as prompt in paying off their accounts.

TABLE 8-27. SELECTED FINANCIAL STATISTICS FOR THE COIL COATING INDUSTRY, 1976-1978[a]

Ratio	Year		
	1976	1977	1978
Sales to inventories	NA	5.9	12.0
Sales to receivables	NA	11.6	7.4
Current assets to current liabilities	2.3	3.2	2.1
Debt to total capitalization (%)	33.5	32.4	30.7

[a] Calculated from financial data on 29 firms (see Section 8.6).

NA = not available.

An important financial parameter for the industry is the weighted average cost of capital (WACC), which was estimated to be 12 percent. The WACC is the return on investment needed to guarantee a supply of investment funds for the industry. The cost of capital is a weighted average of the after-tax costs of the three major sources of capital: common stock, long-term debt, and preferred stock. The methods used to determine the WACC are described in detail in Section 8.6.

8.4.3 Methodology

The methodology used to estimate the impacts of the regulatory alternatives is described in this section. A discounted cash flow (DCF) approach is used to evaluate the profitability of investing in new production facilities and, more specifically, to determine which one of several alternative facilities is the most profitable for the firm. For each size of production facility, the firm can choose one of several possible configurations. These configurations correspond to the "base case" and the control options for which cost data were provided in Section 8.2. Using the DCF approach, the most profitable configuration for each type of production facility can be selected. The resulting choices show which facilities would be constructed by the industry in the absence of the regulatory alternatives and thus constitute a baseline from which the impacts of those alternatives can be measured.

A general description of the DCF approach is provided in Section 8.4.3.1. This background is needed to understand the particular application of the DCF approach, which, as presented in Section 8.4.3.2, is used to estimate the economic impacts. Finally, how the impacts are calculated with this method is discussed in Section 8.4.3.3.

8.4.3.1 Discounted Cash Flow Approach. An investment project generates cash outflows and inflows. Cash outflows include the initial investment and operating expenses. Cash inflows are the revenues from the sales of the output produced by the project, depreciation of the capital equipment, and recovery of the working capital at the end of the project's life. Cash outflows and inflows can occur at any time during the project's lifetime. For this analysis, all flows are assumed to take place instantaneously at the end of each year. Furthermore, all investments are assumed to be conventional investments; that is, they are represented by one cash outflow followed by one or more cash inflows.[38] This assumption insures the existence of a unique internal rate of return for each project.[39] For a project with a lifetime of N years, there are N + 1 points in time at which cash flows occur: at the end of year 0, the end of year 1, and so on through the end of the Nth year.

The initial (and only) investment is assumed to be made at the end of year zero. This cash outflow comprises the sum of the fixed capital cost and the working capital. It is offset by an investment tax credit, which is calculated as a percentage of the fixed capital cost and represents a direct tax saving. The cash flow in year zero can be given by the following equation:

$$Y_o = (FCC + WC) + (TCRED \times FCC). \qquad (8\text{-}1)$$

The variables for this and subsequent equations are defined in Table 8-28.

The project generates its first revenues (and incurs further costs) at the end of year 1. The net cash flows in this and succeeding years can be represented by the following equation:

$$Y_t = (R_t - E_t)\,(1 - T) + D_t T \qquad t = 1, \ldots, N. \qquad (8\text{-}2)$$

The first term of Equation 8-2 represents the after-tax inflows of the project generated by sales of the output after netting out all deductible expenses. Revenues are given by

$$R_t = P \cdot Q \cdot U. \qquad (8\text{-}3)$$

Deductible operating expenses, E_t, are the sum of the fixed and variable operating costs and can be represented by

$$E_t = V \cdot U + F. \qquad (8\text{-}4)$$

Variable costs include expenditures on raw materials, labor (operating, supervisory, and maintenance), and utilities. Fixed costs include expenditures for facility use, insurance, administrative overhead, etc. For

TABLE 8-28. DEFINITIONS

Symbol	Explanation
D_t	Depreciation in year t
DF_t	Discount factor = $(1 + r)^{-t}$
DF	Sum of the discount factors over the life of the project = $\sum_{t=0}^{N} (1 + r)^{-t}$
DSL	Present value of the tax savings due to straight line depreciation = $\sum_{t=0}^{N} D_t T(1 + r)^{-t}$
E_t	Operating expenses in year t
F	Annual fixed costs
FCC	Fixed capital costs
N	Project lifetime in years
NPV	Net present value
P	Price per unit of output
Q	Annual plant capacity
R_t	Revenues in year t
r	Discount rate, or weighted average cost of capital
T	Corporate tax rate
TCC	Total capital cost
TCRED	Investment tax credit
U	Capacity utilization rate
V	Annual variable operating costs
WC	Working capital
X	Minimum [$2,000, 0.2 × FCC]
Y_t	Net cash flow in year t

income tax purposes, E_t is deductible from gross revenues, R_t. Hence, the after-tax cash inflow to the firm can be determined by netting out these expenses and multiplying the result by (1 - T).

Federal income tax laws also allow a deduction for depreciation of the capital equipment (not including working capital). Although depreciation is not an actual cash flow, it does reduce income tax payments (which are cash outflows) since taxes are based on net income after the depreciation allowance is deducted.[40] In Equation 8-2, the expression D_tT represents a firm's annual tax savings resulting from depreciation; it is treated as a cash inflow. In the analysis in this section, the straight-line method of depreciation is used. The salvage value of the facility is assumed to be zero, so the annual depreciation expense is simply given by (FCC - X)/N, where N is the lifetime of the project and X is $2,000 or 20 percent of the fixed capital costs, whichever is smaller.

The net cash flows represented by Equation 8-2 occur at the end of the first through the Nth years. Additional cash inflows occur at the end of the first and Nth year. The additional cash inflow at the end of the first year is the tax savings attributable to the additional first year depreciation deduction of 20 percent of the fixed capital cost or $2,000, whichever is smaller. By law, the basis for calculating normal depreciation allowances must be reduced by the amount of the additional first year depreciation.[41] The additional cash inflow at the end of the Nth year occurs when the working capital, initially treated as a cash outflow, is recovered.

Because these cash flows occur over a future period of time, they must be discounted by an appropriate interest rate to reflect the fact that a sum of money received at some future date is worth less than if that sum were received at the present time. This discount factor, DF_t, can be given by

$$DF_t = (1 + r)^{-t} \qquad t = 0, 1, . . ., N. \qquad (8\text{-}5)$$

The sum of the discounted cash flows from a project is called the net present value of that project. That is,

$$NPV = \sum_{t=0}^{N} Y_t \cdot DF_t \text{ , or}$$

$$NPV = \sum_{t=0}^{N} Y_t (1 + r)^{-t} . \qquad (8\text{-}6)$$

The decision criterion is to invest in the project if it has a positive NPV at a discount rate equal to the weighted average cost of capital.

8.4.3.2 Project Ranking Criterion. The specific application of DCF used in the economic analysis is discussed in this section. What is needed is a criterion for ranking alternative investment projects in terms of profitability. It is assumed that, in the absence of the regulatory alternatives, any firm building a new production facility would invest in the most profitable configuration of that facility. This configuration can be compared with the one to be built to comply with the regulatory alternative; this comparison forms the basis for calculating price and rate of return impacts.

Equation 8-6 can be rearranged and used as the ranking criterion. The procedure begins by substituting the expressions for R and E (given by Equations 8-3 and 8-4, respectively) in Equation 8-2. Next, the expressions for Y_o in Equation 8-1 and Y_t in Equation 8-2 are substituted for Y_t in Equation 8-6. NPV in equation 8-6 is then set equal to zero, and the unit price, P, is solved for by rearranging the terms in Y_t so that the price is on the left-hand side of the equal sign, and all other terms are on the right hand side:

$$P = \frac{Z}{DF \cdot (1-T) \cdot Q \cdot U} + \frac{V \cdot U + F}{Q \cdot U} , \qquad (8\text{-}7)$$

where $Z = -Y_o - DSL - WC(1 + r)^{-N} - X(1 + r)^{-1} \cdot T$ and all other variables are as defined in Table 8-28. The resulting expression for P has two terms. The first, or "capital cost," term is that part of the unit price accounted for by the initial capital outlay (adjusted for the tax savings attributable to depreciation, recovery of working capital, etc.) and includes the return on the invested capital. The second, or "operating cost," term is a function of the fixed and variable operating costs. Hence, for any configuration, the price given by Equation 8-7 can be interpreted as the one that just covers the unit operating costs and yields a rate of return, r, over the project's lifetime on the unrecovered balances of the initial investment.

For each type of facility, Equation 8-7 is used to calculate the unit cost of the coating from each configuration. The results are then ranked in order of cost, from lowest to highest. The most profitable configuration is the one that can coat a square meter of metal coil for the lowest cost.

8.4.3.3 Determining the Impacts of the Regulatory Alternatives. This section describes how the impacts of the regulatory alternatives are estimated with the price ranking method discussed in Section 8.4.3.2. The estimated impacts are presented in Sections 8.4.4 and 8.4.5. Three categories of impacts are estimated: price, ROI, and incremental capital requirements.

Price impacts are calculated directly from Equation 8-7. Given the imputed cost of the coating for each control option, cost increases from the base unit cost of the most profitable line can be calculated.

Whereas price impacts are calculated by assuming that all of the incremental costs associated with a given control option are passed forward to the consumer, ROI impacts are estimated by assuming that the producer absorbs all of the incremental costs, thus lowering the ROI. In this case, the price facing the consumer would not change. For any control option, there may exist a discount rate that would enable the producer to maintain the imputed price of the coating at its baseline level. The baseline price is the price associated with the most profitable line configuration and is determined from the procedure described in Section 8.4.2.2

The baseline price was calculated from Equation 8-7 using a specific value of the discount rate, $\bar{r}$ (equal to the weighted average cost of capital). The calculation of the rate of return impact would begin by setting $P = \bar{P}$ in Equation 8-7, where $\bar{P}$ is the baseline (lowest) price, and by then iteratively solving for the value of r that equates the right-hand side of Equation 8-7 with $\bar{P}$. This value, say r^*, will always be less than $\bar{r}$, the baseline rate of return. The difference between r^* for each control option and $\bar{r}$ constitutes the rate of return impact.

The incremental capital requirements are calculated from the cost data presented in Section 8.2. The additional capital required to meet the standards is used as a partial measure of the financial difficulty firms might face in attempting to conform to the standard. Incremental capital requirements also constitute a barrier for firms entering the coil coating industry. The magnitude of the additional capital relative to the baseline capital requirements is a measure of the size of this barrier.

8.4.4 Economic Impacts on New Facilities

This section presents the estimated impacts of the regulatory alternatives on new production facilities. The firm is confronted with a set of coating line configurations from which it selects the most profitable by applying the ranking method described in Section 8.4.3.2. Each line configuration corresponds to a level of emission control (64 percent reduction, 85 percent reduction, or 95 percent reduction). The profit-maximizing choice is compared with the configuration needed to comply with the regulatory alternatives; the resulting impacts are then estimated with the methods described in Section 8.4.3.3.

Table 8-29 presents the capital and operating costs for the different configurations of the small, medium, and large coating lines. The costs are based on those given in Section 8.2 and are reproduced here to illustrate the form in which they were used in the analysis. The "annual operating costs" reported in Section 8.2 are here classified as "fixed" and "variable." Note that these are not annualized costs; that is, they do not include a capital recovery component. This aspect of cost accounting is implicitly handled in the DCF approach.

The costs for each configuration were inserted into Equation 8-7 to determine the cost of coating one square meter of metal. All calculations assumed straight-line depreciation of the capital equipment over 10 years; a 100 percent capacity utilization rate; an investment tax credit of 10 percent; a corporate tax rate of 46 percent; and a discount rate of 12 percent (equal to the weighted average cost of capital reported in Section 8.4.2.2). Working capital was estimated at 10 percent of the fixed capital cost.

Table 8-30 presents the unit price for each line configuration. These are ranked from lowest (rank = 1) to highest. These prices and rankings

TABLE 8-29. SUMMARY COST DATA FOR NEW FACILITIES ($1,000)

	Line size								
	Small[a]			Medium[b]			Large[c]		
	Capital	Operating cost		Capital	Operating cost		Capital	Operating cost	
Line configuration	cost[d]	Fixed[e]	Variable[f]	cost[d]	Fixed[e]	Variable[f]	cost[d]	Fixed[e]	Variable[f]
Zone incineration (64% reduction)	8,272.0	300.8	1,885.0	11,616.0	422.4	4,571.0	15,312.0	556.8	8,516.0
Thermal incineration (85% reduction)	8,349.0	303.6	1,906.0	11,902.0	432.8	4,681.0	16,170.0	588.0	8,764.0
Thermal incineration (95% reduction)	8,470.0	308.0	1,909.0	12,045.0	438.0	4,678.0	16,324.0	593.6	8,751.0

[a] One coating line with annual capacity = 4,600 × 10^3 m^2.

[b] One line with annual capacity = 14,000 × 10^3 m^2.

[c] One line with annual capacity = 28,000 × 10^3 m^2.

[d] Installed equipment costs from Tables 8-11 and 8-21 plus working capital at 10 percent of installed cost.

[e] 4 percent of installed equipment cost.

[f] From Tables 8-14 and 8-22.

TABLE 8-30. UNIT PRICES AND RANKINGS FOR NEW FACILITIES[a]

	Line size								
	Small[b]			Medium[c]			Large[d]		
		Rank			Rank			Rank	
Line configuration	Price, $/m^2$	CTG	Numerical	Price, $/m^2$	CTG	Numerical	Price, $/m^2$	CTG	Numerical
Zone incineration (64% reduction)	0.854	1	NA	0.532	1	NA	0.439	1	NA
Thermal incineration (85% reduction)	0.863	2	1	0.545	2	1	0.456	2	1
Thermal incineration (95% reduction)	0.870	3	2	0.547	3	2	0.457	3	2

[a] All calculations assumed straight-line depreciation of capital equipment, an investment of tax credit of 10 percent, a corporate tax rate of 46 percent, a project life of 10 years, and a discount rate (the weighted average cost of capital) of 12 percent.

[b] One coating line with annual capacity = 4,600 × 10^3 m^2.

[c] One line with annual capacity = 14,000 × 10^3 m^2.

[d] One line with annual capacity = 28,000 × 10^3 m^2.

NA = not applicable.

are used to estimate the price impacts (Section 8.4.4.1), the ROI impacts (Section 8.4.4.2), and the incremental capital requirements (Section 8.4.4.3) of the regulatory alternatives.

8.4.4.1 Price Impacts. Table 8-31 shows the price impacts of the regulatory alternatives on new facilities in CTG and numerical limit areas. Note that two alternatives apply to facilities in CTG areas, and one alternative to facilities in numerical limit areas. This reflects the difference in the baseline level of control required by States using the CTG (64 percent reduction in emissions) and that required by States specifying a numerical limit on emissions (85 percent reduction). The less stringent standard for the CTG areas also explains why the impacts are greater for new facilities located in those areas than for those in the numerical limit areas. Facilities in CTG areas would have to increase prices by 1.1 to 3.9 percent to maintain the baseline ROI under Alternative II; under Alternative III, the price impact would range between 1.9 and 4.1 percent. The impacts on facilities in numerical limit areas are insignificant; the estimated price increases would range from 0.2 to 0.8 percent.

8.4.4.2 Return on Investment Impacts. Table 8-32 shows the ROI impacts of the regulatory alternatives for new facilities in CTG and numerical limit areas. Again, the impacts are more severe for facilities in CTG areas. The decline in ROI would range from 0.4 to 2.3 percentage points under Alternative II and from 0.7 to 2.4 percentage points under Alternative III. Alternative III would have insignificant ROI impacts for facilities in numerical limit areas, with the ROI declining from 0.1 to 0.3 percentage points from its baseline level of 12 percent.

8.4.4.3 Incremental Capital Requirements. The additional capital outlays required under the regulatory alternatives for facilities in CTG and numerical limit areas are shown in Table 8-33. The incremental capital requirements, as a percentage of the baseline amount, are larger for new facilities in CTG areas than for facilities in numerical limit areas. Under Alternative III, from 2.4 to 6.6 percent more capital is required for new lines in CTG areas, compared with a 1.0 to 1.4 percent increase for new lines in numerical limit areas. In absolute amounts, the incremental capital requirements are also greater for new facilities in CTG areas, ranging from $180,000 to $920,000 under Alternative III. The comparable range for lines in numerical limit areas is $110,000 to $140,000.

TABLE 8-31. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON NEW FACILITIES (%)[a]

	Line size		
Regulatory alternative	Small[a]	Medium[b]	Large[c]
CTG areas			
II. 85% reduction	1.05	2.44	3.87
III. 95% reduction	1.87	2.82	4.10
Numerical limit areas			
III. 95% reduction	0.81	0.37	0.22

[a] One coating line with annual capacity = 4,600 × 10^3 m^2.

[b] One line with annual capacity = 14,000 × 10^3 m^2.

[c] One line with annual capacity = 28,000 × 10^3 m^2.

TABLE 8-32. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON NEW FACILITIES (%)[a]

Regulatory alternative	Line size Small[b]	Medium[c]	Large[d]
CTG areas			
II. 85% reduction	-0.38	-1.21	-2.28
III. 95% reduction	-0.69	-1.41	-2.39
Numerical limit areas			
III. 95% reduction	-0.31	-0.21	-0.12

[a] Table entries are decreases from the baseline ROI of 12 percent.

[b] One coating line with annual capacity = 4,600 × 10^3 m^2.

[c] One line with annual capacity = 14,000 × 10^3 m^2.

[d] One line with annual capacity = 28,000 × 10^3 m^2.

TABLE 8-33. INCREMENTAL CAPITAL REQUIREMENTS OF REGULATORY ALTERNATIVES FOR NEW FACILITIES ($1,000s)[a]

Regulatory alternative	Line size Small[b]	 Medium[c]	 Large[d]
CTG areas			
II. 85% reduction	77.0 (0.9)	286.0 (2.5)	858.0 (5.6)
III. 95% reduction	198.0 (2.4)	429.0 (3.7)	1,012.0 (6.6)
Numerical limit areas			
III. 95% reduction	121.0 (1.4)	143.0 (1.2)	154.0 (1.0)

[a] Calculated from data in Table 8-29. Numbers in parentheses are the incremental capital requirement as a percentage of the baseline capital investment.

[b] One coating line with annual capacity = 4,600 × 10^3 m^2.

[c] One line with annual capacity = 14,000 × 10^3 m^2.

[d] One line with annual capacity = 28,000 × 10^3 m^2.

8.4.4.4 Summary. Regulatory Alternative III, which calls for a 95 percent reduction in emissions, will have the largest overall impact on the industry. Price increases ranging from 0.2 to 4.1 percent would result if all additional costs were passed through; ROI decreases of 0.1 to 2.4 percentage points would occur if the additional costs were absorbed by the producer. Alternative II, on the other hand, would have the least impact on the industry, primarily because facilities in numerical limit areas would not be affected. New lines in CTG areas would have to raise prices from 1.1 to 3.9 percent if all additional costs were passed forward; the ROI would decline from 0.4 to 2.3 percentage points if producers absorbed the incremental costs.

These impacts are subject to two important qualifications. First, the costs for the model plants implicitly assume that only one type of coating would be applied. While this may be true for captive coaters, it is not true for toll coaters, who use many types of coatings. Calculating the unit price for each configuration based on these costs, then, creates a false impression that each coater sets and maintains one price for all of his output. In actuality, as discussed in Section 8.1 and illustrated in Table 8-3, prices for coil coating services vary widely, primarily depending on the type of coating applied. Using a point estimate (the unit prices reported in Table 8-30) to represent an array of prices carries with it the risk that estimates of price and ROI impacts may be greatly over- or underestimated. Second, the unit prices reported in Table 8-30 can be viewed as prices only for toll coaters; a vertically integrated company that owns a coating firm would view the reported "prices" as costs, and the estimated "price" increases as cost increases. The actual price impact would appear in the price of the final product in which the coated coil was an input; the magnitude of this impact would depend, among other things, on the share of the cost of the coated coil relative to the total cost of production of the final product.

The size of the impacts for facilities in CTG areas relative to those for facilities in numerical limit areas also deserves comment. No competitive advantage currently exists for facilities in CTG areas, nor would a facility in a numerical limit area acquire a competitive advantage under Alternative II or III merely because the impacts are smaller. A coil coater does not serve a national market, so there is little if any competition between facilities in CTG and numerical limit areas. That facilities in CTG areas have no competitive advantage is demonstrated by observing that only 30 percent of the coil coating facilities are located in these areas where production costs are presumably lower. It seems clear that another factor, the location of the coil coater close to the customers he serves, is much more important than the air pollution standards of the area in determining the location of new facilities. The implementation of Alternative II or III, then, will tend to equalize the costs of production between CTG and numerical limit facilities, although site-specific factors will still result in considerable price variation.

8.4.5 Economic Impacts on Modified Facilities

This section presents the estimated impacts of Regulatory Alternatives II and III on existing coil coating lines that undergo modification. The modification is an equipment change that increases the line speed (and output) by 20 percent. Table 8-34 gives the capital and operating costs for small, medium, and large lines that undergo modification in CTG and numerical limit areas. These costs are based on those given in Section 8.2. The operating costs represent the variable cost of production for the additional output of the line and include the emissions control costs.

The costs for each line configuration were inserted into Equation 8-7 to determine the unit price of coating a square meter of metal. All calculations assumed straight-line depreciation of the additional capital equipment over 10 years; a 100 percent capacity utilization rate; an investment tax credit of 10 percent; a corporate tax rate of 46 percent; and a discount rate of 12 percent (equal to the weighted average cost of capital from Section 8.4.2.2). Working capital was estimated at 10 percent of the fixed capital cost.

Table 8-35 presents the unit price in dollars per square meter for each configuration and line size in both CTG and numerical limit areas. These are ranked from lowest to highest, i.e., from most to least profitable. These prices and rankings were used to estimate price impacts (Section 8.4.5.1), ROI impacts (Section 8.4.5.2), and incremental capital requirements (Section 8.4.5.3) that would occur under Alternatives II and III.

TABLE 8-34. SUMMARY COST DATA FOR MODIFIED FACILITIES ($1,000s)[a]

	CTG areas						Numerical limit areas					
	Small line[b]		Medium line[c]		Large line[d]		Small line[b]		Medium line[c]		Large line[d]	
Line configuration	Capital cost[e]	Operating cost[f]	Capital cost[e]	Operating cost[f]	Capital cost[e]	Operating cost[f]	Capital cost[e]	Operating cost[g]	Capital cost[e]	Operating cost[g]	Capital cost[e]	Operating cost[g]
Zone incineration (64% reduction)	110.0	223.0	165.0	668.0	220.0	1,338.0	NA	NA	NA	NA	NA	NA
Thermal incineration (85% reduction)	393.8	264.0	633.6	736.0	958.1	1,463.0	110.0	222.0	165.0	665.0	220.0	1,330.0
Thermal incineration (95% reduction)	393.8	276.0	633.6	757.0	958.1	1,505.0	267.3	225.0	354.2	663.0	425.7	1,318.0

[a] The modification is a 20 percent increase in line speed accomplished by replacing the drive motor, gears, and electrical controls. The resulting increase in annual capacity is 920×10^3 m^2 for the small line, $2,800 \times 10^3$ m^2 for the medium line, and $5,600 \times 10^3$ m^2 for the large line.

[b] One coating line with annual capacity = $4,600 \times 10^3$ m^2.

[c] One line with annual capacity = $14,000 \times 10^3$ m^2.

[d] One line with annual capacity = $28,000 \times 10^3$ m^2.

[e] Capital costs taken from Section 8.2.3, including working capital at 10 percent of the installed capital cost.

[f] Operating costs taken from Table 8-23, including the variable costs of production and emission control attributable to the additional output only.

[g] Operating costs taken from Table 8-24, including the variable costs of production and emission control attributable to the additional output only.

NA = not applicable.

TABLE 8-35. UNIT PRICES AND RANKINGS FOR MODIFIED FACILITIES[a]

Line configuration	CTG areas						Numerical limit areas					
	Small line[b]		Medium line[c]		Large line[d]		Small line[b]		Medium line[c]		Large line[d]	
	Price, $\$/m^2$	Rank	Price, $\$/m^2$	Rank	Price, $\$/m^2$	Rank	Price, $\$/m^2$	Rank	Price, $\$/m^2$	Rank	Price, $\$/m^2$	Rank
Zone incineration (64% reduction)	0.268	1	0.251	1	0.247	1	NA	NA	NA	NA	NA	NA
Thermal incineration (85% reduction)	0.377	2	0.311	2	0.297	2	0.266	1	0.250	1	0.246	1
Thermal incineration (95% reduction)	0.3[illegible]0	3	0.318	3	0.305	3	0.306	2	0.263	2	0.251	2

[a] All calculations assume straight-line depreciation of capital equipment, an investment tax credit of 20 percent, a corporate tax rate of 46 percent, a project life of 10 years, and a discount rate (the weighted average cost of capital) of 12 percent.

[b] One coating line with annual capacity = 4,600 × 10^3 m^2.

[c] One line with annual capacity = 14,000 × 10^3 m^2.

[d] One line with annual capacity = 28,000 × 10^3 m^2.

NA = not applicable.

8.4.5.1 Price Impacts. Table 8-36 presents the price impacts for modified facilities in CTG and numerical limit areas. Alternative II is not applicable to facilities in numerical limit areas. Alternative II is not applicable to facilities in numerical limit areas, since the SIPs require an 85 percent reduction in emissions. However, firms that modify facilities in CTG areas would have to raise the price of the additional output by 20.2 to 40.7 percent to maintain the baseline ROI. Alternative III would affect all modified facilities, although the price increases for modified lines in numerical limit areas, which range from 2.0 to 15.0 percent, are significantly smaller than those for lines in CTG areas, which range from 23.5 to 45.5 percent.

8.4.5.2 ROI Impacts. Table 8-37 shows the ROI impacts of the regulatory alternatives on modified facilities. In calculating these impacts, it is assumed that producers attempt to maintain the baseline price when faced with cost increases. For firms in CTG areas, this is the price for the zone incineration configuration reported in Table 8-35; for firms in the numerical limit areas, it is the unit price for the thermal incineration (85 percent reduction) configuration.

As the table shows, the impacts are large. For modified lines in CTG areas, an ROI does not exist under either Regulatory Alternative II or III that would allow the firm to maintain the baseline price. Another way of stating this is that a firm would never have a net cash inflow (see Equation 8-2) over the life of the project by charging the baseline price; it would thus be impossible for the firm to recover its initial capital investment. The impacts for facilities that undergo modification in numerical limit areas are almost as great. The ROI would decrease by 11.9, 9.1, and 6.1 percentage points for the small, medium, and large lines, respectively, from the baseline ROI of 12 percent.

8.4.5.3 Incremental Capital Requirements. Table 8-38 gives the additional capital outlays that would be required under Alternatives II and III if an existing line were modified. The results help explain the severity of the ROI impacts. Modifications of facilities in CTG areas would require increased outlays ranging from 258 to 336 percent under Alternatives II or III over the baseline capital requirement. These increases range from 94 to 143 percent for modifications in numerical limit areas.

TABLE 8-36. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON MODIFIED FACILITIES (%)

Regulatory alternative	CTG areas Small line[a]	CTG areas Medium line[b]	CTG areas Large line[c]	Numerical limit areas Small line[a]	Numerical limit areas Medium line[b]	Numerical limit areas Large line[c]
II. 85% reduction	40.67	23.90	20.24	NA	NA	NA
III. 95% reduction	45.52	26.69	23.48	15.04	5.20	2.03

[a] One coating line with annual capacity = 4,600 × 10^3 m^2.

[b] One line with annual capacity = 14,000 × 10^3 m^2.

[c] One line with annual capacity = 28,000 × 10^3 m^2.

NA = not applicable.

TABLE 8-37. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON MODIFIED FACILITIES (%)[a]

Regulatory alternative	CTG areas			Numerical limit areas		
	Small line[c]	Medium line[d]	Large line[e]	Small line[c]	Medium line[d]	Large line[e]
II. 85% reduction	----[b]	----[b]	----[b]	NA	NA	NA
III. 95% reduction	----[b]	----[b]	----[b]	-11.90	-9.14	-6.09

[a] Table entries are decreases from the baseline ROI of 12 percent.

[b] The ROI is undefined. That is, an ROI does not exist that would allow the facility to maintain the baseline price.

[c] One coating line with annual capacity = 4,600 × 10^3 m^2.

[d] One line with annual capacity = 14,000 × 10^3 m^2.

[e] One line with annual capacity = 28,000 × 10^3 m^2.

NA = not applicable.

TABLE 8-38. INCREMENTAL CAPITAL REQUIREMENTS OF REGULATORY ALTERNATIVES FOR MODIFIED FACILITIES ($1,000s)[a]

	CTG areas			Numerical limit areas		
Regulatory alternative	Small line[b]	Medium line[c]	Large line[d]	Small line[b]	Medium line[c]	Large line[d]
II. 85% reduction	283.8 (258.0)	468.6 (284.0)	738.1 (335.5)	NA	NA	NA
III. 95% reduction	283.8 (258.0)	468.6 (284.0)	738.1 (335.5)	157.3 (143.0)	189.2 (114.7)	205.7 (93.5)

[a] Calculated from data in Table 8-34. Numbers in parentheses are the incremental capital requirement as a percentage of the baseline capital investment.

[b] One coating line with annual capacity = 4,600 × 10^3 m^2.

[c] One line with annual capacity = 14,000 × 10^3 m^2.

[d] One line with annual capacity = 28,000 × 10^3 m^2.

NA = not applicable.

8.4.5.4 Summary. The estimated impacts of the regulatory alternatives on modified facilities were much larger than the estimated impacts for new facilities. The main reason for this is the relatively small investment outlay (between $100,000 and $200,000) required to make the original modification when compared with the additional capital outlays needed to meet the regulatory alternatives (see Table 8-38). However, it cannot be concluded that the modification of an existing plant would not be undertaken. The unit prices reported in Table 8-35 represent point estimates; in actuality, the price charged by a coil coater could be expected to vary widely, depending mainly on the type of coating being applied. A coil coater receiving an average price for the additional output that is greater than the highest price reported in Table 8-35 would make the modification because it would be profitable for him to do so. Hence, the prices in Table 8-35 must be interpreted as the minimum needed to cover the variable production costs and to return 12 percent on the unrecovered balances of the initial investment over the life of the project. Since the estimated prices are tied so closely to the one type of coating implicit in the cost data, and since there are many types of coatings used in the industry, it cannot be concluded that all modifications of existing lines would cease.

8.5 POTENTIAL SOCIOECONOMIC AND INFLATIONARY IMPACTS

Executive Order 12044 requires that the inflationary impacts of major legislative proposals, regulations, and rules be evaluated. The regulatory options would be considered a major action (thus requiring the preparation of an Inflationary Impact Statement) if either of the following criteria apply:

- Additional annualized costs of compliance, including capital charges (interest and depreciation), will total $100 million within any calender year by the attainment date, if applicable, or within 5 years of implementation.
- Total additional cost of production is more than 5 percent of the selling price of the product.

Section 8.5.1 estimates the maximum additional annualized costs of compliance. Section 8.5.2 addresses the expected increase in the product price.

8.5.1 Annualized Cost Criterion

To calculate the additional compliance costs, the number of new sources that would be constructed and the number of existing sources that would be modified each year were taken from Section 8.1.2.2. For new sources, it was estimated that three large lines, two medium lines, and two small lines would be built each year; it was assumed that three lines of each size would be modified each year. To calculate the worst impacts, two assumptions were made: (1) all new and modified sources would come onstream in 1985 and (2) all new and modified facilities would be located in CTG areas.

The incremental annualized costs were determined from the cost data for Alternative III (95 percent reduction) in Tables 8-29 and 8-34. The incremental capital investment for each line size was multiplied by a capital recovery factor of 0.176 (based on an interest rate of 12 percent and straight-line depreciation over 10 years); this result was added to the incremental operating cost to calculate the incremental annualized cost for each line size. The total number of lines and the incremental cost per line are shown in Table 8-39. The last column of Table 8-39 gives the product of the number of lines and the incremental cost per line. The sum of the figures in this column, $18 million, is well under the $100 million threshold. Thus, none of the regulatory alternatives qualifies as a major action by this criterion.

8.5.2 Product Price Criterion

To determine if the implementation of Alternative III would increase product prices by more than 5 percent, it was necessary to construct a weighted average price increase for the overall industry price level from the price impacts presented in Tables 8-31 and 8-36. This was done by multiplying each price impact under Alternative III by a weighting factor and summing the results. The weighting factor has three components: (1) the proportions of the increase in annual output accounted for by new and by modified facilities, (2) the proportions of the increase in annual output accounted for by facilities in CTG and in numerical limit areas, and (3) the proportions of the increase in annual output accounted for by small, medium, and large facilities.

The increases in annual output accounted for by new and modified facilities were calculated from information in Section 8.1.2.2. It was

TABLE 8-39. INCREMENTAL ANNUALIZED COST OF COMPLIANCE WITH REGULATORY ALTERNATIVE III, 1985[a]

	No. of lines[b]	Incremental cost per line, 1,000s[c]	Cost per line size, 1,000s[d]
New facilities			
Large	15	450.9	6,763.5
Medium	10	198.5	1,985.0
Small	10	66.2	662.0
Modified facilities			
Large	15	297.6	4,464.0
Medium	15	171.9	2,578.5
Small	15	103.2	1,548.0
Total incremental cost			18,001.0

[a] Calculations assumed that all facilities were located in CTG areas.

[b] Taken from Section 8.1. It is assumed that the number of new and modified facilities projected annually all take place in the fifth year after implementation.

[c] Calculated from costs presented in Tables 8-29 and 8-34. A capital recovery factor of 0.176 was calculated using a depreciation of 10 years and an interest rate of 12 percent. This factor was used to annualize the incremental capital investment required under Alternative III.

[d] The product of the number of lines and the incremental annualized cost per line.

assumed that three large facilities, two medium facilities, and two small facilities would be constructed each year; in addition, three large, three medium, and three small facilities would be modified each year. The total additional output from new facilities and from modified facilities was divided by the total annual increase in output to calculate two weights: (1) new facilities would account for 81.3 percent of total additional output and (2) modified facilities would account for 18.7 percent.

To estimate the proportions of the increase in annual output from facilities in CTG and in numerical limit areas, it was assumed that the present proportions of facilities in these areas would be maintained in future new source construction and existing source modification. Thus, 30 percent of the increase in annual output would occur in CTG facilities and 70 percent would occur in numerical limit facilities. Finally, the proportions of the increase in annual output accounted for by small, medium, and large new sources and by small, medium, and large modified sources were determined by reapplying the assumptions used to determine the first part of the weighting factor described above. For example, small new facilities were estimated to account for 13.8 million m^2 (4.6 million m^2 per line times 3 new lines per year) of the 121.2 million m^2 additional annual output from new facilities, which is 7.6 percent of the additional output.

The three components were multiplied together to determine a unique weight for each facility size that was dependent on whether it was a new or modified facility and on whether it was located in a CTG or numerical limit area. The weighting factors and the unweighted price impacts are shown in Table 8-40. The weighted price impacts in this table are the products of the weight and the unweighted price impact. The sum of these products, 3.1 percent, is the estimated percentage increase in the overall industry price level.

Because these price impacts are not insignificant, even if they do not exceed the 5 percent threshold, it is of some interest to see what impact on the Consumer Price Index (CPI) an increase in the price of coil coating services would have. The input-output tables of the U.S. economy were used to simulate this impact. A price increase of 3.1 percent was assumed to take place in the metal coating and allied services industry (SIC 3479). (Recall that the coil coating industry accounts only for roughly 20 percent

TABLE 8-40. OVERALL PRICE IMPACT OF REGULATORY ALTERNATIVE III

	Unweighted price impacts, %[a]	Weights[b]	Weighted price impacts, %[c]
New facilities			
CTG areas			
Small	1.87	0.019	0.03
Medium	2.82	0.056	0.16
Large	4.10	0.169	0.69
Numerical limit areas			
Small	0.81	0.043	0.03
Medium	0.37	0.131	0.05
Large	0.22	0.394	0.09
Modified facilities			
CTG areas			
Small	45.52	0.006	0.25
Medium	26.69	0.017	0.45
Large	23.48	0.034	0.79
Numerical limit areas			
Small	15.04	0.013	0.20
Medium	5.20	0.039	0.20
Large	2.03	0.079	0.16
Total		1.000	3.10

[a] Unweighted price impacts for new facilities taken from Table 8-31. Price impacts for modified facilities taken from Table 8-36.

[b] The product of three factors: (1) proportions of additional annual output accounted for by new and modified facilities, (2) the proportions of the additional annual output accounted for by facilities in CTG and in numerical limit areas, and (3) the proportions of the additional annual output accounted for by small, medium, and large facilities. See text for a description of how these components were estimated.

[c] Product of the unweighted price impact and the weighting factor.

of the value of shipments of this industry group; the actual price increase that would occur in SIC 3479 is thus much lower than the 3.1 percent used in this exercise.) After the increase has worked its way through the economy, the results show that the CPI would increase by one-hundredth of one percent, a nominal amount. For these reasons, it is concluded that the regulatory alternatives do not qualify as a major action by this criterion.

8.6 FINANCIAL DATA FOR COIL COATING FIRMS

This section provides the statistics for individual firms that were used to compile the averages for the coil coating industry given in Section 8.4.2.2. This information is given in Table 8-41.

The weighted average cost of capital (WACC) is the return on a firm's investment necessary to guarantee a continued inflow of investment funds. The cost of capital for any new project is the cost of equity, debt, and preferred stock, weighted by the percentage of funds generated by each type of financing. That is,

$$k_c = k_e \frac{E}{I} + k_i \frac{D}{I} + k_p \frac{P}{I} , \qquad (8\text{-}8)$$

where

k_c = cost of capital
k_e = cost of equity capital
k_i = cost of debt capital
k_p = cost of preferred stock capital
E = the amount of equity used to finance a given investment
D = the amount of debt used to finance a given investment
P = the amount of preferred stock used to finance a given investment
I = the total funds needed for the investment.

The first step in estimating Equation 8-8 is to determine the relevant weights for the three types of financing. It is assumed that the proportion of debt, equity, and preferred stock to be used on any new project will be the same as currently exists in the firm's capital structure. This implies that the firm is currently using the optimal mix of financing. Figures for the three types of funds came from the Value Line Investment Survey for each firm's fiscal years ending in 1978. Common equity included the par value of common stock, retained earnings, capital surplus, self-insurance

TABLE 8-41. FINANCIAL STATISTICS FOR COIL COATING FIRMS

	Sales/ inventories		Sales/ receivables		Current assets/ current liabilities			Debt/total capitalization, %			1978 weighted average cost of capital, %
	1977	1978	1977	1978	1976	1977	1978	1976	1977	1978	
Alcan	3.0	3.6	5.5	4.9	2.3	2.3	2.2	39.7	34.4	29.2	13.1
Alcoa	5.3	6.1	6.9	6.8	2.2	2.2	2.1	40.7	38.6	34.3	11.5
Amax	3.9	4.6	8.3	7.1	2.2	2.4	1.5	28.7	29.2	25.3	10.9
Armco	6.1	8.9	8.1	8.5	2.0	1.8	1.7	27.4	25.9	23.6	12.5
Arvin Industries	6.5	6.1	8.7	7.5	3.5	5.4	4.0	44.0	42.0	37.9	NA
Bendix	5.0	5.3	8.5	7.7	1.9	1.8	1.7	26.4	23.0	26.9	13.4
Bethlehem Steel	7.9	9.7	9.9	9.2	2.0	1.5	1.6	27.5	34.6	29.8	12.6
Chamberlain	NA	NA	NA	5.6	NA	32.0	3.0	NA	NA	30.3	NA
Chromalloy	5.6	5.8	7.8	7.7	1.8	2.0	1.9	48.8	48.1	46.5	11.5
Consolidated Foods	7.7	7.0	12.1	9.2	2.3	2.4	1.9	21.8	19.5	26.5	12.1
Cyclops	NA	NA	8.1	7.9	1.9	1.8	1.8	30.0	30.0	30.0	12.8
Freuhauf	7.4	7.3	8.5	6.9	2.0	1.8	1.8	46.2	44.5	45.7	10.9
Groff	9.6	7.2	2.3	3.1	2.8	2.8	2.3	NA	NA	10.0	NA
Hexel	10.2	100.1	7.8	8.9	NA	2.2	2.4	NA	33.7	33.7	NA
Inland Steel	8.1	9.3	7.8	9.5	1.9	1.9	1.7	30.3	34.9	34.2	11.2
Kaiser	4.8	5.1	10.0	8.6	NA	0.2	1.6	NA	NA	NA	NA
Kirsch	3.9	40.0	6.2	6.1	4.0	4.1	3.3	29.2	27.1	27.8	12.9
LTV	NA	NA	113.5	7.6	NA	1.4	1.6	NA	NA	NA	NA
Marathon	3.9	4.2	6.8	7.1	2.3	1.9	1.6	29.7	21.9	16.4	NA
Martin Marietta	6.9	8.8	6.3	6.2	2.2	1.9	1.6	27.0	23.0	14.9	13.8
National Steel	6.2	6.6	9.9	8.4	1.7	1.8	1.7	37.1	36.1	34.2	11.1
Phelps Dodge	4.2	7.0	8.2	7.2	1.4	1.5	2.1	38.5	36.7	40.8	10.7
Republic Steel	6.1	7.4	11.4	10.3	1.8	2.2	2.9	22.0	25.3	24.1	12.8
Revere Copper	4.1	4.7	9.7	7.4	2.7	1.8	2.7	57.0	46.2	56.6	10.2
Reynolds Metals	3.6	4.2	7.9	7.1	2.6	2.6	2.4	46.3	42.6	41.9	11.5
Sears	6.8	6.6	2.6	2.6	1.6	1.6	1.6	24.0	22.4	23.4	13.1
Stanley	NA	NA	9.4	9.8	NA	2.8	3.0	NA	NA	NA	NA
Teledyne	NA	NA	8.8	8.6	NA	2.0	2.0	30.0	30.0	30.0	13.3
Wolverine	NA	NA	3.6	7.8	2.8	2.0	2.1	18.0	28.0	24.0	NA
Average	5.9	12.0	11.6	7.4	2.3	3.2	2.1	33.5	32.4	30.7	12.1

NA = not available.

reserves, and capital premium, while debt included all obligations due more than a year from the company's balance sheet date. Preferred stock represented the net number of preferred shares outstanding at year end multiplied by the involuntary liquidating value per share.

The next step in calculating Equation 8-8 is to estimate the cost of equity financing. The capital-asset pricing model (CAPM) was used to estimate this cost. The CAPM examines the necessary returns on a firm's stock in relation to a portfolio comprised of all existing stocks. The required return on equity is

$$k_e = i + \beta (k_m - i) \quad , \tag{8-9}$$

where

i = the expected risk free interest rate

$k_m - i$ = the expected excess return on the market

β = the firm's beta coefficient.

Figures for Equation 8-9 were developed in the following manner. The expected risk-free rate was assumed equal to the yield on a 3-month Treasury Bill, as reported in the October 1, 1979, Wall Street Journal. The current yield was 10.46 percent. This corresponds to the yield from a bond with no possibility of default and offering no chance of a capital loss and is therefore riskless. The firm's beta coefficients came from the September 24, 1979, Value Line Investment Survey. The expected excess return equalled 2.9646 percent, the 5-year average (July 1974 through June 1979) of the monthly excess returns on the Standard & Poor's 500 Stock Index multiplied by 12.

The third step in estimating Equation 8-8 is calculating the cost of debt financing. This would be a relatively easy estimation if interest rates did not change over time. Past yields on old issues of bonds would suffice. Since interest rates have been increasing, it was felt that a more forward-looking rate was required. The method selected was to take the average yield as given in the October 1 through September 3, 1979, Moody's Bond Survey for the firm's bond ratings class as the necessary yield the firm must offer on long-term debt. The firm's ratings class came from the September 1979 Moody's Bond Record or the 1979 Moody's Industrial

Manual. This was used as the necessary yield on long-term debt. Table 8-42 presents the yields by ratings class and the prime rate used for the cost of debt funds.

The yield on long-term debt does not represent the aftertax cost of debt financing since interest charges are tax deductable. To arrive at the after-tax cost, the yield must be multiplied by one minus the marginal tax rate,

$$k_i = k(1 - t) \quad ,$$

where

k = the yield on bonds
t = the marginal tax rate.

It is assumed that the firms in the sample are profitable, so that taxes must be paid, and that their marginal tax rate is 48 percent.

The last step in estimating Equation 8-8 is to arrive at the cost of preferred stock financing. Unlike debt, preferred stock does not have a maturity date, so that the current yield should approximate the yield on new issues. The yield is

$$k_p = \frac{D}{P} \quad ,$$

where

D = stated annual dividend
P = the price of a share of preferred stock.

The figures for dividends and share price came from the October 1, 1979, Wall Street Journal or, if not included in this source, from the January 1, 1979, listing in the Daily Stock Price Record.

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TABLE 8-42. YIELDS BY RATING CLASS FOR COST OF DEBT FUNDS, 1979
(prime rate = 15.00 %)

Ratings class	Yield, %
AAA	9.25
AA	9.59
A	9.72
BAA	10.38
BA	11.97
B	12.395

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APPENDIX A

EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

APPENDIX A

EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

The contractor for the Metal Coil Surface Coating source category, Research Triangle Institute (RTI), began work on the project on October 12, 1978. Table A-1 lists major events and accomplishments in the evolution of the Background Information Document (BID). The initial activities consisted of formulating a Phase I Work Plan and making contacts with industry officials. The National Coil Coaters Association (NCCA) agreed to provide technical and economic information and provided such at various stages throughout the project. The Air Pollution Technical Information Center conducted a literature search on the coil coating industry in November 1978. Project personnel reviewed this information during the next month.

A series of seven visits to coil coating plants was begun with two visits in December 1978. In January and February of 1979 priority was given to completing Phase I, with the submission of the Source Category Survey Report and the Phase II and III Work Plan. Four more facilities were visited in March 1979, and one in October 1979. The plants were selected to provide information on a wide range of emission control systems and types of coatings. In March 1979, the project staff met with industry representatives at NCCA Headquarters in Philadelphia to discuss the types of information needed from the Association.

An emission test plan was outlined in April 1979; however, the first test was delayed until August 1979, at which time it was carried out successfully by Midwest Research Institute (MRI) in cooperation with RTI. In May 1979 a meeting was held with officials of Midland-Ross Corporation, a vendor of coating equipment, ovens, and emission control systems. Much of the information regarding control systems was obtained from vendors by letters and telephone conversions during the remainder of 1979.

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TABLE A-1. MAJOR EVENTS AND ACCOMPLISHMENTS IN THE EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

Month	Event
October 1978	Work begun by Research Triangle Institute (RTI). National Coil Coaters Association (NCCA) contacted.
November 1978	Phase I Work Plan submitted. Literature search carried out.
December 1978	Plant visits conducted to Roper Eastern Corporation and Chesapeake Finished Metals, Baltimore. Formal request for information sent to NCCA.
January 1979	Phase II and III Work Plan completed.
February 1979	Source Category Survey Report completed. Phase I completed.
March 1979	Plant visits made to Precoat Metals, St. Louis; Modern Materials, Detroit; and Rollcoater, Greenfield and Kingsbury, Indiana. Meeting held at NCCA headquarters.
April 1979	Emission Test Plan completed. Preliminary model plants and regulatory alternatives defined.
May 1979	Meeting with Midland-Ross Corporation officials.
June 1979	Survey and economic data obtained from EPA Effluent Guidelines Division and Water Economics Branch.
July 1979	Requests for samples sent to coating manufacturers.
August 1979	Model plants and regulatory alternatives defined. Emission test at Precoat Metals begun.
September 1979	Emission test at Precoat Metals completed. Requests for cost information sent to equipment vendors.
October 1979	NCCA Technical Meeting, Chicago, attended. Technical background chapters of Background Information Document (BID) completed. Plant visit made to Kaiser Aluminum, Toledo.
December 1979	Chapters 3-6 of BID sent to industry officials for comment. Cost study completed.
January 1980	REECO representative gave presentation at EPA on REECO emission control system.
April 1980	Economic analysis completed. NAPCTAC package completed.
June 1980	NAPCTAC meeting held.
June 1980	Steering Committee package mailed on consent agenda. No meeting held.

APPENDIX B
INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

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INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

Table B-1 lists the locations in this document of certain information pertaining to environment impact, as outlined in Agency Guidelines (39 FR 37419, October 21, 1974).

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TABLE B-1. LOCATIONS OF INFORMATION CONCERNING ENVIRONMENTAL IMPACT WITHIN THE BACKGROUND INFORMATION DOCUMENT

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419, October 21, 1974)	Location within the Background Information Document
Background and summary of regulatory alternatives	Chapter 1, Section 1.1
Statutory basis for proposing standards	Chapter 2, Section 2.1
Relationships to other regulatory agency actions	Chapters 3, 7, and 8
Industry affected by the regulatory alternatives	Chapter 3, Section 3.1, and Chapter 8, Section 8.1
Specific processes affected by the regulatory alternatives	Chapter 1, Section 1.1, and Chapter 3, Section 3.2.

APPENDIX C
EMISSION SOURCE TEST DATA

APPENDIX C
EMISSION SOURCE TEST DATA

C.1 INTRODUCTION

Six emission tests of coil coating lines with thermal incinerators have been identified, and a test sponsored by the U.S. Environmental Protection Agency (EPA) was completed during the course of this study. Each test is discussed below.

C.1.1 Emission Test 1

In 1971, Scott Research Laboratories performed a series of emission tests on two coil coating lines with thermal incinerators. Control unit 031 was designed to heat 4.2 m^3/s (9,000 scfm) of gases to 760° C (1,400° F), with a design residence time of 0.8 s. Control unit 033 had a residence time of 0.8 s at a design flow of 1.2 m^3/s (2,600 scfm) and at a temperature of 760° C (1,400° F). The coatings in each case were white acrylic coatings containing 40 percent solids by weight. The methods of analysis are summarized in Table C-1.

During the testing, Unit 031 was operating at less than design flow rate while Unit 033 was operating at greater than design flow rate. For reasons not explained in the report, the operating temperatures were estimated at approximately 38° C (100° F) greater than the measured outlet temperatures. The results of the testing are summarized in Tables C-2 and C-3. Unit 031 achieved an average 99.5 percent reduction in hydrocarbons; Unit 033 achieved only 89 percent, probably because of the lower actual operating temperature and residence time due to overloading. Unit 033 produced a higher level of products of partial combustion than Unit 031, although compounds present in the inlet streams predominated in the outlet streams in each case. Higher concentrations of nitrogen oxides were produced in Unit 031, probably as a result of the higher actual operating temperatures.

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TABLE C-1. PROCEDURES USED IN EMISSION TEST 1

Parameter	Method of measurement
Nitric oxide & nitrogen dioxide	Modified Saltzman Procedure
Carbon monoxide	Continuous infrared analyzer
Carbon dioxide	Continuous infrared analyzer
Total aldehydes	MBTH method
Total hydrocarbons	Continuous total hydrocarbon analyzer, flame ionization
Individual hydrocarbons	Gas chromatography
Odor	Modified ASTM Standard Method D 1391-57
Gas velocity	Pitot tube traverse of duct
Gas temperature	Thermocouple traverse of duct

TABLE C-2. CONDITIONS AND COMPOSITION OF GASES AT THE INLET AND OUTLET OF CONTROL UNIT 031, EMISSION TEST 1

Run no.	Inlet flow rate		Temperature, °C		Nitric oxide, ppm		Nitrogen dioxide, ppm		Aldehydes, ppm H_2CO		Carbon monoxide, ppm		Carbon dioxide, %		Total nonmethane hydrocarbons, ppm C_3H_8		Odor reduction, dilutions
	m³/s	(scfm)	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
1		-	-	688	-	31	-	17	-	30	180	690	-	-	2,120	15	300
2	3.40	(7,200)	316	721	-	44	8.3	3.5	--	20	40	30	2.70	-	2,470	12	300
3	3.20	(6,790)	321	682	2.2	22	4.8	5.1	31	11	100	250	2.25	4.05	-	17	200
4	3.36	(7,120)	321	699	2.0	13	3.8	4.9	32	5.1	100	250	2.70	4.35	-	2	300
5	3.13	(6,640)	307	699	2.4	17	8.2	12	34	10	120	480	2.55	4.00	2,720	-	300
Avg.	3.27	6,940	316	698	2.2	27	6.3	8.5	32	15	110	340	2.55	4.13	2,440	11	280

TABLE C-3. CONDITIONS AND COMPOSITION OF GASES AT THE INLET AND OUTLET OF CONTROL UNIT 033, EMISSION TEST 1

Run no.	Inlet flow rate		Temperature, °C		Nitric oxide, ppm		Nitrogen dioxide, ppm		Aldehydes, ppm H_2CO		Carbon monoxide, ppm		Carbon dioxide, %		Total nonmethane hydrocarbons, ppm C_3H_8		Odor reduction, dilutions
	m³/s	(scfm)	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
1	1.40	(2,960)	304	582	-	-	-	-	-	-	285	2,450	2.59	3.33	-	-	-
2	1.49	(3,070)	293	566	2.3	10	2.1	3.6	38	1.9	270	5,360	2.35	3.06	(2,200)	230	8
3	1.34	(2,840)	293	582	2.8	11	4.2	8.7	51	23	569	5,930	(2.20)	-	2,570	304	100
Avg.	1.41	(2,960)	297	577	2.6	11	3.2	6.2	45	13	375	4,580	2.38	3.20	2,385	267	54

NOTE: Parenthesis indicates values estimated on the basis of incomplete data.

C.1.2 Emission Test 2

Environmental Technology and Engineering Corporation conducted an emission test of a REECO Re-therm system in April 1976. The Re-therm unit incorporates thermal incineration and regenerative heat recovery. Gas samples were collected upstream and downstream of the unit in heated (121° C, 250° F), stopcocked, 500 mℓ gas sampling bottles. Approximately 40 ℓ of sample were drawn through the sampling train before the stopcock was closed. A gas chromatograph equipped with a flame ionization detector was used in the analysis of samples. Flow rate determinations were made with a standard pitot tube to do velocity traverses of 12 points each. The results for each sample are given in Table C-4. The air flow rates and retention times in the incinerator are not reported. The types of coatings used during the testing are listed in Figure C-1. The incinerator system achieved an average solvent reduction of 94 percent of the hydrocarbons entering the device.

C.1.3 Emission Test 3

An emission test was done by Midland-Ross Corporation on a thermal incinerator controlling emissions from a coil coating line in November 1976. The line was running a steel strip 1.2 m (48 in.) wide at 1.0 m/s (200 ft/s). The wet coating thickness was 0.089 mm (.0035 in.), and the coating contained 50 percent solids (basis unknown). Details of the testing procedure are not known. Based on three samples, the average inlet concentration to the incinerator was 2,700 ppmv; the average outlet concentration was 36 ppmv (both concentrations probably as methane). The average solvent reduction across the incinerator was 98 percent.

C.1.4 Emission Test 4

An emission test of a 1.2 m (48 in.) aluminum coating line was carried out in January 1977 by Clayton Environmental Consultants of Southfield, Michigan. The incinerator temperature was 700° C (1,300° F). A single pair of samples were taken, one upstream and one downstream of the incinerator; the corresponding concentrations of nonmethane hydrocarbon were 4,530 ppm as methane (upstream) and 560 ppm as methane (downstream). The solvent reduction across the incinerator was thus 88 percent. Total hydrocarbons were determined by an on-line hydrocarbon analyzer based on a flame

TABLE C-4. RESULTS OF EMISSION TEST 2

Sample time	Incinerator exhaust temperature °C	(°F)	Concentrations hydrocarbons,[a] ppmv Inlet	Outlet	Efficiency %
0910	700	(1,300)	400	61	85
1020	700	(1,300)	420	54	87
1105	700	(1,300)	673	23	97
1150	700	(1,300)	653	10	98
1235	700	(1,300)	540	47	91
1255	700	(1,300)	560	7	99
1415	700	(1,300)	450	10	98
1435	700	(1,300)	477	23	95
Avg	700	(1,300)	522	29	94

[a] FID calibrated using propane.

Time of test	Prime coat Front side	 Back side	Finish coat Front side	 Back side
0910 though 1200	Epoxy 141	Epoxy 141	Polyester 189	Polyester 189
1200 through 1600	Epoxy 153	Epoxy 141	Fluorocarbon 618	Polyester 189

Chemical Composition of Coatings

Epoxy Primer 141	31.9%	Nonvolatiles	Polyester 189	53.0%	Nonvolatiles
	4.5%	Butanol		2.9%	Butanol
	17.0%	Xylol		3.4%	Xylol
	13.4%	Solvesso 100		2.6%	Solvesso 100
	28.8%	Diacetone		31.5%	Solvesso 150
	4.4%	Butyl cellosolve		4.2%	Butyl carbitol
				2.4%	Butyl cellosolve
Epoxy Primer 153	33.7%	Nonvolatiles	Fluorocarbon 618	37.0%	Nonvolatiles
	44.8%	Cellosolve acetate		51.0%	Isophorene
	16.3%	Solvesso 150		6.8%	Xylol
	2.7%	Toluol		5.1%	Butyl cellosolve
	2.5%	Isopropyl alcohol			

Figure C-1. Description of coatings used during emission test 2.

ionization detector. Methane was measured with the same analyzer preceded by an activated carbon column; nonmethane hydrocarbons were calculated as the difference. The gas flow rate to the incinerator was measured at 5.29 m^3/s (11,200 scfm). Measurements of the flow rate and hydrocarbon concentration of the air being exhausted from the coating room indicated that approximately 20 percent of the total nonmethane hydrocarbons that could potentially have reached the incinerator actually were exhausted to atmosphere through exhaust ducts.

C.1.5 Emission Test 5

H & M Engineering and Research Company performed an emission test of a coil coating line in October 1978. The line had been retrofitted with multiple, oven-mounted incinerators (zone incinerators). Although coating usage was recorded, the only gas streams actually tested were the exhaust streams from the final afterburners. The results of the testing are given in Table C-5. Flow rates were measured by velocity traverses. Each hydrocarbon data point in Table C-5 represents a sample that was collected in a glass chromatography collector and analyzed with flame ionization calibrated for methane. Based on the solvent usage rates measured at the coating rooms, the solvent reduction across the entire topcoat system was greater than 99 percent at afterburner temperatures of 482° C (900° F) or greater.

C.1.6 Emission Test 6

An emission test was performed on a total of nine incinerators that were being used to burn recycled hydrocarbons to two ovens. The incinerators were mounted external to the ovens. The average of the inlet concentrations to the five incinerators on the prime coat oven was 733 ppmv; the average of the outlet concentrations from the five incinerators was 55 ppmv, for an efficiency of 92 percent. The average temperature was 716° C (1,320° F). The average of the inlet concentrations to the four incinerators on the topcoat oven was 3,718 ppmv; the average of the outlet concentrations was 32 ppmv, for an effectiveness of 99 percent. The exhaust temperature was 760° C (1,400° F).

C.1.7 EPA Sponsored Emission Test

An emission test was done by Midwest Research (MRI) Institute of Kansas City, Missouri, in August and September 1979. The work was done under contract with the Emission Measurement Branch of EPA. The coating line being

TABLE C-5. RESULTS OF EMISSION TEST 5

Gas stream tested	Gas flow rate		Total hydrocarbons	Total hydrocarbon emissions		Solvent input		Afterburner temperature		Percent reduction
	m^3/s	(scfm)	ppmv as CH_4	kg/h	(lb/h)	kg/h	(lb/h)	° C	(° F)	
Final exhaust from prime coat system	3.07	(6,510)	1.0	.002	(.005)	95	(210)	649	(1,200)	99.9
Final exhaust from topcoat system	3.80	(8,060)	150	0.50	(1.1)	223	(492)	482	(900)	99.8
	3.83	(8,110)	20	.059	(.13)	223	(492)	593	(1,100)	99.9
	2.97	(6,300)	0.45	.001	(.002)	223	(492)	649	(1,200)	99.9

tested was equipped with ovens having zone incinerators and individual final afterburners with waste heat boilers.

Emission measurements were made before and after each final afterburner. Temperatures in the afterburners were changed for separate test runs to measure the efficiency of these units at several temperatures. A material balance of coatings was done for each run to estimate the overall efficiency of the control systems. Sampling was done to measure quantity and solvent concentrations of the coatings used; nitrogen oxides at the afterburner outlets; volumetric flow rates at the afterburner inlets and outlets; and volatile organic compound (VOC) concentrations at the afterburner inlets and outlets. VOC sampling and analyses were done according to Method 25 for total gaseous nonmethane organic emissions.

The results of the testing indicate that the final afterburners, when operated at 760° C (1,400° F), achieved destruction efficiencies of 93 to 96 percent. The resulting overall destruction efficiencies of the system were estimated at greater than 99 percent. There are inconsistencies in the data between the Method 25 results and the THC (FID only) results at lower concentrations for all afterburner temperature settings. These inconsistencies are being investigated by EPA. Further interpretation of the data is awaiting release of the final report.

As best as can be determined from the reports, the MRI emission test is the only test performed according to Proposed Method 25, "Determination of Total Gaseous Nonmethane Organic Emissions as Carbon: Manual Sampling and Analysis Procedure."

C.2 REFERENCES

1. A Study of the Gaseous Emissions of the Coil Coating Process and Their Control. Scott Research Laboratories, Inc. Plumsteadville, Pennsylvania. Report Number SRL 1233 07 1071. October 1971. pp. 3-13 through 3-18, AIII-2 through AIII-15, and AIII-46 through AIII-55.

2. Report of Hydrocarbon Emission Test. Environmental Technology and Engineering Corporation. Elm Grove, Wisconsin. May 1976.

3. Letter from Zuffante, V. M., Midland-Ross Corporation, to Fletcher, George, Metal Koting. May 31, 1977. Emission test.

4. Hydrocarbon Emission Study, Rolled Aluminum Strip-Coating Process. Clayton Environmental Consultants, Inc. Southfield, Michigan. February 1977.

5. Stack Sampling Report. H & M Engineering and Research Company. Address Unknown. October 1978.

6. Emission Test of a Coil Coating Plant in St. Louis, Missouri. Midwest Research Institute. Kansas City, Missouri. November 1979.

APPENDIX D
EMISSION MEASUREMENT AND CONTINUOUS MONITORING

APPENDIX D
EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 EMISSION MEASUREMENT METHODS

During the standard support study for the coil coating industry, the U.S. Environmental Protection Agency (EPA) conducted a test for volatile organic compounds (VOCs) at one coil coating plant. The primary purpose of this test program was to determine the VOC control efficiency of the two incinerators employed to control prime coat and finish coat curing oven emissions.

VOC emission tests were conducted at three different incinerator temperatures for both the prime coat and the finish coat incinerator to establish an estimate of the relationship between incinerator temperature and VOC control efficiency. Each incinerator was tested separately.

A second objective of the test program was to determine the amount of coating used during the individual test runs. No attempt, however, was made to assure that the coatings tested represented the "average" coating at this plant or in the industry.

Three test runs were conducted at each of three different incinerator temperatures on each of the two incinerators for a total of 18 test runs. Each run spanned approximately 30 minutes. During each run, tests were conducted at the main exhaust of the prime coat (or finish coat) curing oven (the inlet to the incinerator) and at the exhaust of the applicable incinerator. These tests included determining the average VOC concentration with Reference Method 25, determining percent oxygen and carbon dioxide with Fyrite equipment, and determining moisture content with Reference Method 4. In addition, the nitrogen oxide and continuous VOC concentrations were measured at the incinerator exhaust with a chemiluminescent and flame ionization analyzer (FIA), respectively. The volumetric flow rate at the inlet of the incinerator being tested was determined daily with Reference Method 2. Additional testing was conducted during the last day of the test

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program to estimate VOC emissions from the finish oven quench exhaust by (1) measuring the VOC concentration according to proposed Reference Method 25 and FIA and (2) measuring flow measurements according to Reference Method 2.

The coating used was determined by measuring the volume of coating used during the run. Samples of the coating were collected at the start and end of each run. Some of these samples were analyzed for VOC content to determine the applicability of Reference Method 24.

D.2 PERFORMANCE TEST METHODS

Performance test methods are needed to determine the VOC content of the coating and to determine the overall control efficiency of an add-on VOC control system.

D.2.1 Coating VOC Content

The volatile organic content of the coating may be determined by the manufacturer's formulation or from Reference Method 24, "Determination of Volatile Organic Content (as Mass) of Paint, Varnish, Lacquer, or Related Products."

Reference Method 24 combines several American Society for Testing and Materials (ASTM) standard methods that determine the volatile matter content, density, volume of solids, and water content of the paint, varnish, lacquer, or related coating. From this information, the mass of VOCs per unit volume of coating solids is calculated. The estimated cost of analysis per coating sample is $150. For aqueous coatings, there is an additional $100 cost per sample for water content determination. Because the testing equipment is standard laboratory apparatus, no additional purchasing costs are expected.

D.2.2 Control Efficiency of Add-on VOC Control System

If the VOC content of the coatings used exceeds the level of the recommended standard, the efficiency of the add-on control system must be determined. This information would be used in conjunction with the VOC content of the coating used to determine compliance with the recommended standard.

For those types of control systems that do not destroy or change the nature of VOC emissions, the recommended procedure is a material balance system where the mass of the VOCs recovered by the control system is determined and used in conjunction with the mass of VOCs in the coating used over the same period of time. The length of time during which this material balance is conducted will be dependent upon the Agency decision on whether to require continual compliance or to demonstrate compliance during an initial performance test. Examples of control systems where this procedure would be applicable are refrigeration and carbon adsorption systems.

A different approach is recommended for those control systems (such as incinerators) that alter the VOC emissions. Ideally, the procedure would directly measure all VOCs emitted to the atmosphere. However, this procedure would require measurement of the VOC emissions that escape capture prior to the incinerator (control system) by construction of a complex ducting system and measurement of the VOC emissions exhausting to the atmosphere from the control system.

The recommended procedure requires simultaneous measurement of the mass of VOCs (as carbon) entering the control system and exiting the control system to the atmosphere. Methods 1, 2, 3, and 4 are recommended to determine the volumetric flow measurements. Reference Method 25 is recommended to determine the VOC (as carbon) concentration. These results are then combined to give the mass of VOCs (as carbon) entering the control system and exiting the control system to the atmosphere. The control efficiency of the control system is determined from these data.

The average of three runs should be adequate to characterize the control efficiency of the control system. The length of each run would be dependent upon the operational cycle of the control system employed. Minimum sampling time would be in the range of 30 minutes and would be dependent upon the size of the evacuated tanks and the sampling rate employed to obtain a sample. The control agency should also consider the representativeness of the solvents and coatings used during the test program. It is assumed that the manufacturers of the oven and incinerator will design the system based on a miximum organic loading that would occur at the maximum line speed with use of the highest percent solvent content coating and the lowest molecular weight solvent (which are typically the most difficult to combust). The designer would also assume 100 percent capture (i.e., no fugitive losses). Although the actual testing time using Reference

Method 25 is only a minimum of 90 minutes, the total time required for one complete performance test is estimated at 8 hours, with an estimated overall cost of $4,000.

D.3 MONITORING SYSTEMS AND DEVICES

The purpose of monitoring is to ensure that the emission control system is being properly operated and maintained after the performance test. One can either directly monitor the regulated pollutant or, instead, monitor an operational parameter of the emission control system. The aim is to select a relatively inexpensive and simple method that will indicate that the facility is in continual compliance with the standard.

For carbon adsorption systems, the recommended monitoring test is identical to the performance test. A solvent inventory record is maintained, and the control efficiency is caluclated every month. Excluding reporting costs, this monitoring procedure should not incur any additional costs for the affected facility since these process data are normally recorded anyway and since the liquid volume meters were already installed for the earlier performance test.

For incinerators, two monitoring approaches were considered: (1) directly monitoring the VOC content of the inlet, outlet, and fugitive vents so that the monitoring test would be similar to the performance tests; and (2) monitoring the operating temperature of the incinerator as an indicator of compliance. The first alternative would require at least two continuous hydrocarbon monitors with recorders (about $4,000 each) and frequent calibration and maintenance. Instead, it is recommended that a record be kept of the incinerator temperature. The temperature level for indication of compliance should be related to the average temperature measured during the performance test. The averaging time for the temperature for monitoring purposes should be related to the time period for the performance test--90 minutes, in this case. Since a temperature monitor is usually included as a standard feature for incinerators, it is expected that this monitoring requirement will not incur additional costs for the plant. The cost of purchasing and installing an accurate temperature measurement device and recorder is estimated at $1,000.

D.4 REFERENCES

1. (Proposed) Method 25--Determination of Total Gaseous Nonmethane Organic Emissions as Carbon: Manual Sampling and Analysis Procedure. Federal Register, 40 CFR Part 60, Vol. 44, No. 195. October 5, 1979. p. 57808.

2. (Proposed) Method 24 (Candidate 2)--Determination of Volatile Organic Compound Content (as mass) of Paint, Varnish, Lacquer, or Related Products. Federal Register, 40 CFR Part 60, Vol. 44, No. 195. October 5, 1979. p. 57807.

APPENDIX E
REVISED REGULATORY ALTERNATIVES

APPENDIX E
REVISED REGULATORY ALTERNATIVES

E.1 INTRODUCTION

During the background study conducted for the metal coil surface coating industry, the best system of continuous emission reduction was determined to be incineration with heat recovery and the use of coating rooms that are ventilated into the oven or incinerator. Consequently, the regulatory alternatives that were considered during the background study were based on the use of such control systems. The original regulatory alternatives considered were as follows:

I. No NSPS.

II. An emission limit equivalent to an 85 percent overall reduction in the emissions from the average industry coating formulation.

III. An emission limit equivalent to a 95 percent reduction in the emissions from the average industry coating formulation.

Regulatory Alternative II is based on the use of an incinerator with a 95 percent VOC removal efficiency, which emission test data indicate can consistently be achieved. This alternative relies upon the normal industry practice for capturing VOC emissions. Information in the literature indicates that under these conditions a capture efficiency of about 90 percent could be expected.

During site visits to two coil coating plants, three coil coating lines were identified that have their coating application stations enclosed in rooms and have all of the ventilating air from the rooms passing into the ovens. This configuration should result in almost complete capture of the VOC emissions. Regulatory Alternative III was therefore based on the use of coating rooms that are ventilated into the oven or incinerator and the use of a 95 percent efficient incinerator.

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When the Background Information Document (BID) and recommended standards for the coil coating industry were presented to the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) for review, representatives of the National Coil Coaters Association (NCCA) presented new data indicating that the basis of the regulatory alternatives may not be consistently applicable throughout the industry. Specifically, the industry data indicate that the coil coating lines that have all of the coating room ventilation passing through the oven are not representative of the industry in that, in most installations, the coating room ventilation requirement is much greater than the requirement for oven makeup air. This statement was verified through contacts with several vendors of coil coating equipment. Because all the air that passes through the oven and incinerator must be heated, a severe energy penalty would be imposed if coil coaters were required to pass all of the coating room ventilation air through the oven or incinerator. The NCCA submittal suggested that, with the use of coating rooms and proper hooding of the coating application stations, a capture efficiency of 95 percent could consistently be achieved.[1]

Other information submitted by the NCCA indicated that if the emission limits for a standard are based on the use of incinerators with a 95 percent efficiency, very few if any of the waterborne coatings available to the coil coating industry could achieve compliance.[2] It was earlier learned that approximately 15 percent of the annual production of coil coated metal is coated with waterborne coatings. The NCCA and several vendors of coatings for the coil industry stated that the recommended limits were so far beyond the existing state of the art in low-VOC content coatings that research and development efforts on these coatings would be stopped. Data solicited from coating vendors indicate that the VOC content of available waterborne coatings ranges from 0.07 kilogram/liter (kg/ℓ) of coating solids to 0.54 kg/ℓ of coating solids and that 90 percent of them are in the range of 0.11 to 0.28 kg/ℓ of coating solids.[3 4 5 6 7] These figures are in fact well above the recommended limit of 0.07 kg/ℓ of coating solids.

In view of the new data obtained during and subsequent to the NAPCTAC meeting, it became necessary to consider several additional regulatory alternatives. A total of five alternatives were considered. These are as follows:

I. No NSPS.

II. An emission limit equivalent to an 85 percent overall reduction in the emissions from the average industry coating formulation.

III. An emission limit the same as Regulatory Alternative II for plants that use higher VOC content coatings and incineration and a separate emission limit for plants that use low-VOC content coatings.

IV. An emission limit equivalent to a 90 percent overall reduction in the emissions from the average industry coating formulation.

V. An emission limit the same as Regulatory Alternative IV for plants that use higher VOC content coatings and incineration and a separate emission limit for plants that use low-VOC content coatings.

As can be seen, Regulatory Alternatives I and II are the same as those originally considered. Regulatory Alternative III is the same as Alternative II for plants that use higher VOC content coatings but also contains a separate emission limit for plants that use low-VOC content coatings. This separate limit would be based on the VOC content of existing coatings of that type.

Regulatory Alternative IV is similar to the original Regulatory Alternative III and is based on the use of a 95 percent efficient incinerator and coating rooms. The capture efficiency of the system is estimated to be 95 percent because all of the coating room ventilation would not be required to pass through the oven or control device.

Regulatory Alternative V is the same as Alternative IV for plants that use higher VOC content coatings but also contains a separate emission limit, based on the VOC content of existing coatings, for plants that use low-VOC content coatings.

The environmental, energy, and economic impacts of each of the above regulatory alternatives were evaluated. The results of these evaluations are presented in the following subsections.

E.2 ENVIRONMENTAL, ENERGY, AND ECONOMIC IMPACTS

The estimated impacts of each of the regulatory alternatives on atmospheric emissions of VOCs are given in Table E-1. The procedures used to estimate these impacts are the same as those described in Chapter 7. No other environmental impacts would be expected from any of the regulatory alternatives.

TABLE E-1. ESTIMATED ENVIRONMENTAL IMPACTS IN THE FIFTH YEAR (Mg/yr [ton/yr)]

Regulatory alternative	Emissions from new plant capacity	Reduction in emissions from modified plants	Overall impact on emissions	Emission reduction relative to baseline
I. No NSPS (baseline)	+4,570(+5,035)	---	+4,570(+5,035)	0
II. 85% control	+3,315(+3,655)	-660(-730)	+2,655(+2,925)	-1,915(-2,110)
III. 85% control, separate limit for waterbornes	+3,380(+3,725)	-625(-690)	+2,755(+3,035)	-1,815(-2,000)
IV. 90% control	+2,210 (+2,435)	-1,245(-1,375)	+960(+1,060)	-3,605(-3,975)
V. 90% control, separate limit for waterbornes	+2,440(+2,690)	-1,125(-1,240)	+1,315(+1,450)	-3,250(-3,585)

Tables E-2 and E-3 present the rates of fuel and electrical energy consumption for uncontrolled coil coating lines and the rates for each level of control considered in the regulatory alternatives. The data are presented for each of the model plant sizes. Table E-4 gives the overall impact on national energy consumption that would result from each of the regulatory alternatives. The energy impact on individual plants is the same for Regulatory Alternatives II and III and for Regulatory Alternatives IV and V. The differences in the national energy impact result from the fact that fewer plants are impacted under Regulatory Alternatives II and IV than under Regulatory Alternatives III and V. It was assumed that under Regulatory Alternatives II and IV, no plants would be able to comply with the standards by using low-VOC content coatings. This assumption probably results in an overestimate of the energy impacts because it is likely that some plants could comply with low-VOC content coatings, although it is not possible to estimate the number of such plants. Under Regulatory Alternatives III and V it was assumed that 15 percent of the plants could comply with the standards by using low-VOC content coatings.

The cost and economic analyses of the regulatory alternatives were made by selecting a specific control methodology by which plants could achieve compliance with each alternative. The control options selected are presented in Table E-5. Tables E-6, E-7, and E-8 show, for each model plant size, the operating parameters for each of the control options that use control devices.

The installed costs for each of the control systems are given in Table E-9 for each model plant size. The annual operating costs are given in Table E-10. The total annualized costs of each control option are given in Tables E-11, E-12, and E-13 for small, medium, and large model plants, respectively. It was assumed that no costs are associated with the use of low-VOC content coatings as a control technique.

Table E-14 presents the capital costs for a new coil coating line for each model plant size and gives the capital costs of the emission control equipment to achieve each level of control considered for plants that use solvent-borne coatings.

A comparison of the cost data contained in Tables E-9 through E-14 with the corresponding costs for the original regulatory alternatives

TABLE E-2. RATE OF FUEL ENERGY USAGE OF MODEL COIL COATING LINES[a]

	Level of Control							
	No emission control		64 percent reduction by incineration at ovens		85 percent overall reduction by incineration at afterburner		90 percent overall reduction by incineration at afterburner with coating rooms	
Model line size	kW	(10^6Btu/h)	kW	(10^6Btu/h)	kW	(10^6Btu/h)	kW	(10^6Btu/h)
Small	2,100	(7.2)	1,000	(3.4)	1,600	(5.5)	1,550	(5.3)
Medium	6,700	(23)	3,200	(11)	4,700	(16)	4,550	(16)
Large	14,000	(48)	7,000	(24)	10,000	(34)	9,700	(33)

[a] Energy rates during plant operating time.

TABLE E-3. RATE OF ELECTRICAL ENERGY USAGE OF MODEL COATING LINES[a]

	Level of Control			
	No emission control	64 percent reduction by incineration at ovens	85 percent overall reduction by incineration at afterburner	90 percent overall reduction by incineration at afterburner with coating rooms
Model line size	kW	kW	kW	kW
Small	190	190	300	300
Medium	680	680	900	900
Large	1,300	1,300	1,800	1,800

[a] Energy rates during plant operating time.

TABLE E-4. ESTIMATED ANNUAL INCREASE IN NATIONAL FUEL CONSUMPTION DUE TO INDUSTRY GROWTH[a]

Regulatory alternative	Increase in fuel consumption First year TJ (billion Btu)	 Fifth year TJ (billion Btu)
I. No NSPS	700 (660)	3,500 (3,300)
II. 85% control	886 (840)	4,430 (4,200)
III. 85% control, separate waterborne limit	770 (730)	3,850 (3,650)
IV. 90% control	870 (820)	4,340 (4,110)
V. 90% control, separate waterborne limit	755 (715)	3,775 (3,575)

[a] Assumptions:

1. Wherever 85 or 90 percent reduction is required, new and modified/reconstructed lines using solvent-borne coatings install thermal incineration systems. These systems include primary and secondary heat recovery or equivalent heat recovery.
2. Systems with 90 percent control include coating rooms.
3. CTG levels of control are achieved by coating rooms and ovens using solvent combustion.
4. Incineration temperature for 85 and 90 percent control is 760° C (1,400° F).
5. Lines using waterborne coatings meet NSPS limits by choice of coating formulation rather than by installation of emission control equipment.

TJ = terajoule, 10^{12} joules.

TABLE E-5. REGULATORY ALTERNATIVES AND CONTROL OPTIONS CONSIDERED IN THE ECONOMIC ANALYSIS

Regulatory alternative	Control option
I. No NSPS (SIP regulations apply) SIP = CTG limits	1. Multiple zone incinerators and coating rooms
SIP = Numerical limits	2. Thermal incineration with heat recovery
II. Limiting emissions to the equivalent of an 85 percent reduction in the emissions from the average industry coating formulation of 40 percent solids and 60 percent VOC	2. Thermal incineration with heat recovery
III. Same as II with a separate limit for waterborne coatings	3. Thermal incineration with heat recovery of waterborne coatings
IV. Limiting emissions to the equivalent of a 95 percent reduction in the emissions from the average industry coating formulation	4. Thermal incineration with heat recovery and coating rooms
V. Same as IV with a separate limit for waterborne coatings	5. Thermal incineration with heat recovery and coating rooms or waterborne coatings

TABLE E-6. KEY PARAMETERS FOR CONTROL BY MULTIPLE ZONE INCINERATORS AND COATING ROOMS

Parameter	Line size		
	Small	Medium	Large
Oven exhaust temperature	316° C (600° F)	316° C (600° F)	316° C (600° F)
Exhaust volume, each oven	2.4 m^3/s (5,000 scfm)	4.7 m^3/s (10,000 scfm)	9.4 m /s (20,000 scfm)
Effectiveness of solvent capture	95 percent	95 percent	95 percent
Effectiveness of solvent destruction	64 percent	64 percent	64 percent
Average solvent input reaching oven	0.016 ℓ/s (15.1 gal/h)	0.048 ℓ/s (45.4 gal/h)	0.11 ℓ/s (101 gal/h)
Average heat released by solvent combustion	720 kW (2.5 MM Btu/h)	2,200 kW (7.4 MM Btu/h)	4,700 kW (16 MM Btu/h)
Electric power required above that of standard ovens	Approx. 0	Approx. 0	Approx. 0

MM Btu = million Btu/h.

TABLE E-7. KEY PARAMETERS FOR CONTROL BY THERMAL INCINERATION WITH HEAT RECOVERY

Parameter	Line size		
	Small	Medium	Large
Oven exhaust temperature	316° C (600° F)	316° C (600° F)	316° C (600° F)
Incineration temperature	760° C (1,400° F)	760° C (1,400° F)	760° C (1,400° F)
Exhaust volume, each oven	2.4 m^3/s (5,000 scfm)	7.1 m^3/s (15,000 scfm)	15.6 m^3/s (33,000 scfm)
Primary heat exchanger duty	1,000 kW (3.5 MM Btu/h)	2,900 kW (10 MM Btu/h)	6,700 kW (23.MM Btu/h)
Secondary heat exchanger duty	1,800 kW (6.3 MM Btu/h)	5,600 kW (19 MM Btu/h)	12,000 kW (42 MM Btu/h)
Effectiveness of solvent capture	90 percent	90 percent	90 percent
Effectiveness of solvent destruction in incinerator	95 percent	95 percent	95 percent
Average solvent input reaching oven	.014 ℓ/s (13.6 gal/h)	.043 ℓ/s (40.9 gal/h)	.096 ℓ/s (90.0 gal/h)
Average heat released by solvent combustion	970 kW (3.3 MM Btu/h)	2,900 kW (9.9 MM Btu/h)	6,400 kW (22 MM Btu/h)
Electric power required above that of standard ovens	106 kW	225 kW	510 kW
Volume of preheated air to ovens	4.1 m^3/s (8,600 scfm)	12 m^3/s (26,000 scfm)	27 m^3/s (58,000 scfm)
Temperature of preheated air to ovens	382° C (720° F)	382° C (720° F)	382° C (720° F)

MM Btu/h = million Btu/h.

TABLE E-8. KEY PARAMETERS FOR CONTROL BY THERMAL INCINERATION WITH HEAT RECOVERY AND COATING ROOMS

	Line size		
Parameter	Small	Medium	Large
Oven exhaust temperature	316° C (600° F)	316° C (600° F)	316° C (600° F)
Incineration temperature	760° C (1,400° F)	760° C (1,400° F)	760° C (1,400° F)
Exhaust volume, each oven	2.4 m^3/s (5,000 scfm)	7.1 m^3/s (15,000 scfm)	15.6 m^3/s (33,000 scfm)
Primary heat exchanger duty	1,000 kW (3.5 MM Btu/h)	2,900 kW (10 MM Btu/h)	6,700 kw (23 MM Btu/h)
Secondary heat exchanger duty	1,800 kW (6.3 MM Btu/h)	5,600 kW (19 MM Btu/h)	12,000 kW (42 MM Btu/h)
Effectiveness of solvent capture	95 percent	95 percent	95 percent
Effectiveness of solvent destruction in incinerator	95 percent	95 percent	95 percent
Average solvent input reaching oven	0.15 ℓ/s (14.4 gal/h)	0.46 ℓ/s (43.2 gal/h)	0.10 ℓ/s (95.5 gal/h)
Average heat released by solvent combustion	1,035 kW (3.5 MM Btu/h)	3,050 KW (10.4 MM Btu/h)	6,700 kW (23 MM Btu/h)
Electric power required above that of standard ovens	106 kW	225 kW	510 kW
Volume of preheated air to ovens	4.1 m^3/s (8,600 scfm)	12 m^3/s (26,000 scfm)	27 m^3/s (58,000 scfm)
Temperature of preheated air to ovens	382° C (720° F)	382° C (720° F)	382° C (720° F)

MM Btu/h = million Btu/h.

TABLE E-9. CAPITAL COSTS OF CONTROL OPTIONS

Control option	Percent overall solvent destruction	Size model line	Installed cost, $1,000s
Multiple zone incinerators and coating rooms	64	Small	214
		Medium	289
		Large	405
Thermal incineration with heat recovery	85	Small	278
		Medium	548
		Large	1,178
Thermal incineration with heat recovery and coating rooms	90	Small	388
		Medium	680
		Large	1,322

TABLE E-10. ANNUAL OPERATING COSTS OF CONTROL OPTIONS

Control level	Model line size	Annual operating costs, $1,000s			
		Electricity	Fuel	Labor, maintenance, materials	Total
64%	Small	0	(25)	10	(15)
	Medium	0	(143)	14	(129)
	Large	0	(304)	20	(284)
85%	Small	17	(25)	14	6
	Medium	36	(83)	28	(19)
	Large	82	(178)	60	(36)
90%	Small	17	(26.5)	20	10
	Medium	36	(88)	35	(17)
	Large	82	(188)	67	(39)

TABLE E-11. ANNUALIZED COST OF VOC CONTROL OPTIONS FOR SMALL MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Overall effectiveness of VOC reduction		Annualized capital costs, $1,000s	Direct cost (savings), $1,000s	Total annualized cost (savings), $1,000s	Overall cost (savings)/unit VOC removal	
		Mg/yr	ton/yr				$/Mg	$/ton
Multiple zone incinerators and coating rooms	64	176	194	37	(15)	22	120	110
Thermal incineration with heat recovery	85	235	259	48	6	54	230	208
Thermal incineration with heat recovery and coating rooms	90	261	288	68	10	78	295	270

[a] Facilities that use waterborne coatings were not considered for add-on controls.

TABLE E-12. ANNUALIZED COSTS OF VOC CONTROL OPTIONS FOR MEDIUM MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Overall effectiveness of VOC reduction		Annualized capital costs, $1,000s	Direct cost (savings), $1,000s	Total annualized cost (savings), $1,000s	Overall cost (savings)/unit VOC removal	
		Mg/yr	ton/yr				$/Mg	$/ton
Multiple zone incinerators and coating rooms	64	530	584	50	(129)	(79)	(149)	(135)
Thermal incineration with heat recovery	85	708	780	95	(19)	76	107	97
Thermal incineration with heat recovery and coating rooms	90	787	866	118	(17)	101	122	117

[a] Facilities that use waterborne coatings were not considered for add-on controls.

TABLE E-13. ANNUALIZED COSTS OF VOC CONTROL OPTIONS FOR LARGE MODEL LINE

Control option for facilities that use solvent-borne coatings[a]	Percent overall solvent destruction	Overall effectiveness of VOC reduction		Annualized capital costs, $1,000s	Direct cost (savings), $1,000s	Total annualized cost (savings), $1,000s	Overall cost (savings)/unit VOC removal	
		Mg/yr	ton/yr				$/Mg	$/ton
Multiple zone incinerators and coating rooms	64	1,060	1,168	70	(284)	(214)	(202)	(183)
Thermal incineration with heat recovery	85	1,411	1,556	205	(36)	169	120	109
Thermal incineration with heat recovery and coating rooms	90	1,568	1,729	230	(39)	191	115	110

[a] Facilities using waterborne coatings were not considered for add-on controls.

TABLE E-14. CAPITAL COSTS OF NEW COIL COATING FACILTIES

	Costs for each size model line, $1,000s		
Cost item	Small	Medium	Large
Mechanical equipment--line	2,700	4,000	5,150
Ovens	630	800	1,090
Installation of mechanical equipment and ovens	1,110	1,600	2,080
Total basic line cost	4,440	6,400	8,320
Building cost	2,870	3,870	5,200
Total facility cost less control equipment	7,310	10,270	13,520
Total facility cost, including control equipment, to meet Control Options 1, 2, and 3[a]			
Control Option 1--64 percent overall destruction	7,520	10,560	13,920
Control Option 2--85 percent overall destruction	7,590	10,820	14,700
Control Option 3--90 percent overall destruction	7,700	10,950	14,840

[a] Applicable only to lines that use solvent-borne coatings.

contained in Tables 8-11 through 8-21 shows that, for plants that use solvent-borne coatings, the costs associated with Regulatory Alternatives II and III are the same as the costs associated with the original Regulatory Alternative II. Such a comparison further shows that, for plants that use solvent-borne coatings, the costs associated with Regulatory Alternatives IV and V are the same as the costs associated with the original Regulatory Alternative III except for a very small difference in fuel consumption. This difference in fuel consumption is, at most, about 5 percent, and the difference in total annualized costs is much smaller than 5 percent. Because these cost differences are well within the estimated accuracy of the overall data collection and analysis procedures, the economic analyses described in Chapter 8 are applicable to the regulatory alternatives discussed in this appendix. The price impacts and the return on investment (ROI) impacts that were estimated for the original Regulatory Alternative II are applicable to Regulatory Alternatives II and III for plants that use solvent-borne coatings, and the impacts estimated for the original Regulatory Alternative III are applicable to Regulatory Alternatives IV and V for plants that use solvent-borne coatings. The difference between the economic impacts of Regulatory Alternatives II and III is that fewer plants would have an economic impact under Alternative III than under Alternative II. This difference occurs because, under Alternative III, some plants could achieve compliance with the standard by using low-VOC content coatings rather than switching to solvent-borne coatings and incineration. The difference between the economic impacts of Regulatory Alternatives IV and V occurs for the same reason.

The result of these differences is that the national impact on product price could be up to 15 percent smaller for Regulatory Alternatives III and V than the values for II and IV, respectively. In Table 8-40, the price increase estimated to result from the original Regulatory Alternative III is 3.1 percent. This same price increase is estimated to occur as a result of Regulatory Alternative IV. Under Regulatory Alternative V, the national price increase could be reduced to 2.6 percent.

E.3 REFERENCES

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